U.S. DEPARTMENT OF COMMERCE
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PB-263 321

# Wastewater Treatment Facilities
# Granby Sanitation District
# Granby, Colorado

Environmental Protection Agency, Denver, CO

Prepared For
Engineering-Science, Inc., Berkeley, California

Feb 76

212005

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PB 263 321

# DRAFT ENVIRONMENTAL IMPACT STATEMENT

# GRANBY WASTEWATER TREATMENT FACILITIES

GRANBY
COLORADO

MARCH 1976

U.S. ENVIRONMENTAL
PROTECTION AGENCY

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SPRINGFIELD, VA. 22161

# SUMMARY

# DRAFT

# ENVIRONMENTAL IMPACT STATEMENT

on

# WASTEWATER TREATMENT FACILITIES
# GRANBY SANITATION DISTRICT
# GRANBY, COLORADO

EPA Project No. C-080346

Prepared by

U.S. ENVIRONMENTAL PROTECTION AGENCY

REGION VIII, DENVER

March 1976

Prepared with the Assistance
of

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Berkeley, California 94710

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Los Angeles, California 90048

**BIBLIOGRAPHIC DATA SHEET**

1. Report No.

2.

3. Recipient's Accession No.
PB-263 321

4. Title and Subtitle
Wastewater Treatment Facilities Granby Sanitation District, Granby, Colorado

5. Report Date
Feb 76

6.

7. Author(s)

8. Performing Organization Rept. No.

9. Performing Organization Name and Address
Environmental Protection Agency
Denver, Colorado
Region VIII

10. Project/Task/Work Unit No.
EPA-C-080346

11. Contract/Grant No.

12. Sponsoring Organization Name and Address
Engineering-Science, Incorporated
Berkeley, California

13. Type of Report & Period Covered

14.

15. Supplementary Notes Prepared in cooperation with Engineering-Science, Inc., Berkeley, Calif., and Socio-Economic Systems, Inc., Los Angeles, Calif.
(PC A13/MF A01)

16. Abstracts

The Granby Sanitation Disctict has applied to the U.S. Environmental Protection Agency for a grant to help construct a new wastewater treatment facility to serve future residential and commercial needs in the designated planning area. The Plan specified nitrification to reduce ammonia concentrations in the effluent, dechlorination to prevent toxicity to aquatic biota and provision of enclosures for certain treatment units to prevent cold-weather disruption of the physical and biological processes.

17. Key Words and Document Analysis. 17a. Descriptors

*Environmental impact statement - draft,

Sewage treatment,
Colorado,
Waste water,
Colorado River Basin,
Public health,
Nitrification,
Environmental impacts,
Land use,
Economic conditions.

17b. Identifiers/Open-Ended Terms

*Sewage treatment plants,
*Granby(Colorado).

17c. COSATI Field/Group 13 B

18. Availability Statement
National Technical Information Service
Springfield, Virginia 22161

19. Security Class (This Report)
UNCLASSIFIED

20. Security Class (This Page)
UNCLASSIFIED

21. No. of Pages
291p

22. Price
9.25/3.00

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## NAME OF THE ACTION

The proposed action is known as the Granby Wastewater Treatment Facility. It is an Administrative action, under the authority of Public Law 92-500, (Water Pollution Control Act Amendments of 1972) Section 201.

## A BRIEF DESCRIPTION OF THE ACTION

### Background and History

The Granby Sanitation District has applied to the U.S. Environmental Protection Agency for a grant to help construct a new wastewater treatment facility to serve future residential and commercial needs in the designated planning area.

The Colorado River Basin Water Quality Management Plan adopted in final form in August 1975, recommended a new wastewater treatment plant downstream of the existing facility. The Plan recommends joint facilities for wastewater management for Granby and Val Moritz. This recommendation makes the provision of separate treatment facilities for Val Moritz subject to specific approval by the Water Quality Control Commission of the State Department of Health. Therefore, at this time, the very possibility of land development and population expansion in the southern part of the planning area in part depends upon the provision of new wastewater treatment facilities. Hence, these facilities are essential for such growth. The potential future service area of such facilities therefore necessarily becomes the scene of the secondary impacts.

The Plan specified nitrification to reduce ammonia concentrations in the effluent, dechlorination to prevent toxicity to aquatic biota and provision of enclosures for certain treatment units to prevent cold-weather disruption of the physical and biological processes. On the basis of these recommendations and effluent characteristics of existing Granby discharges, the Colorado State Department of Health initially placed the Granby Sanitation District high on the Fiscal Year 1975 priority list for wastewater treatment works (Step 1 and Step 2) grants. Subsequently, the priority listing for Granby was eliminated, due in part to improved plant performance.

### Problem Description/Key Issues

Five key interrelated issues are identified with the proposed new sewerage works for Granby Sanitation District. These are as follows: (1) land uses which might be affected through the provision of excess available sewerage capacity, encouraging introduction of additional population pressures, (2) population projections made in earlier years which now appear to be overstated, (3) economic effects of construction of sewerage facilities on the basis of inflated projections, (4) government support of speculative projects through provision of sewerage service in advance of construction of new second-home subdivisions and, (5) potential despoilment of the pristine air, water and aesthetic amenities of a picturesque mountain setting.

## Area Affected

The project is located in the eastern part of Grand County, Colorado. A vicinity map of the project area is shown on Figure 1. The planning area recommended in the Colorado River Basin Water Quality Management Plan includes a large expanse of mountainous terrain to the north of Granby which is expected to remain largely unpopulated. The heart of the planning area encompasses the Granby Quadrangle (USGS standard 7.5 minute topographic map), shown on Figure 2, and will be the portion most intensively affected by the planned developments, the new treatment facilities and their potential interrelationships. Therefore, most of the comments in this document will concentrate on this particular part of the planning area while assuming that the northern portion will more probably remain undeveloped through 1995.

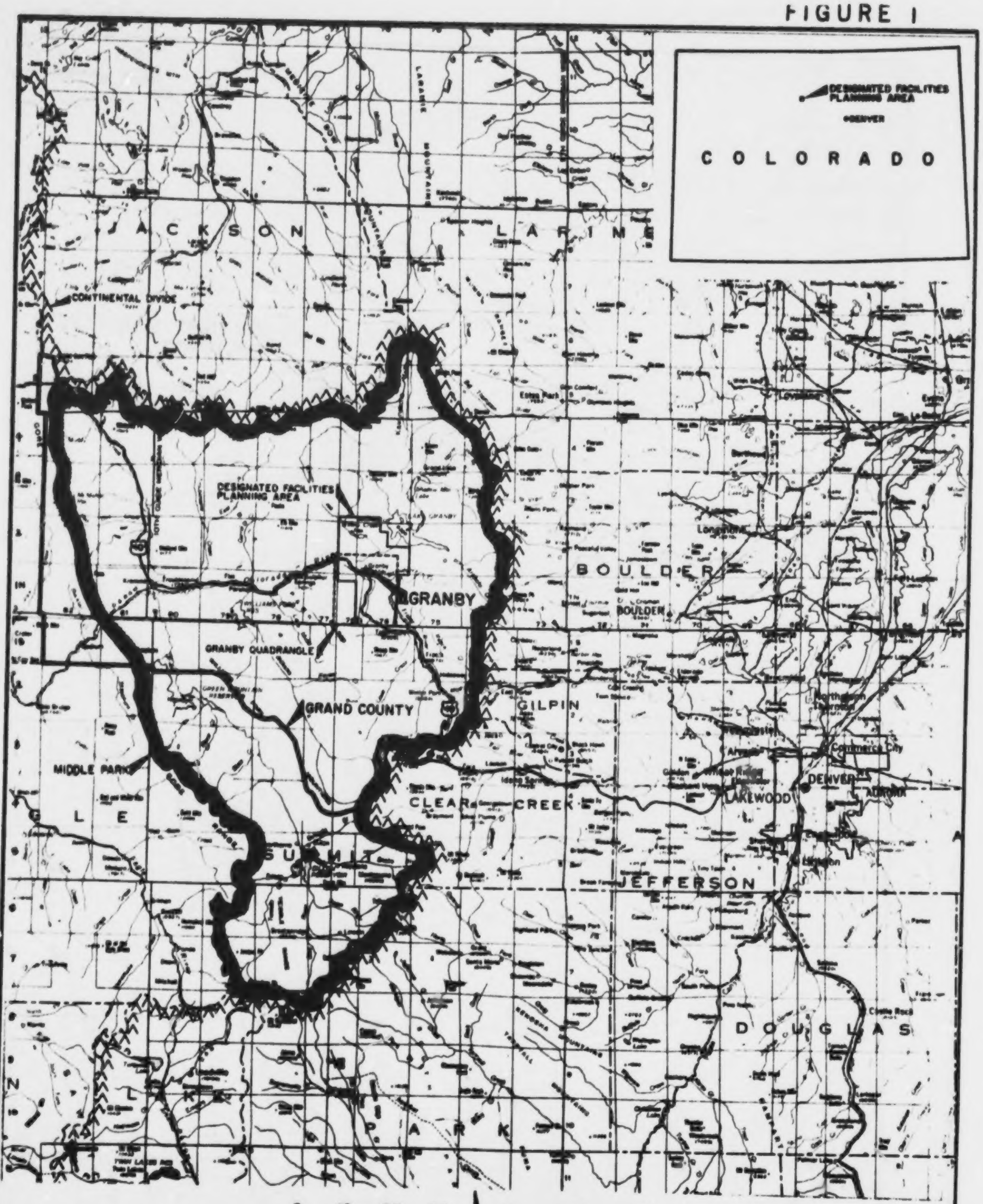
The planning area is situated near the crest of the Southern Rocky Mountains, cradled by the Continental Divide. The mountain ranges surrounding the planning area are the Rabbit Ears Range to the north, the Front Range on the east, the Williams Fork Mountains on the southwest and the Gore Range on the west. The north-central portion of the Southern Rocky Mountain Province contains the Fraser hydrologic subbasin, one of the headwaters of the Colorado River, which in turn contains the planning area.

## Proposed Action

The proposed action involves construction of an advanced wastewater treatment facility to replace the existing plant and to accommodate an eventual 5,700 cu m/day [1.5 mgd] flow. The project implementation may take the form of (1) one-stage construction of a 5,700 cu m per day [1.5 mgd] treatment plant with river discharge, (2) a three-stage facilities construction over a 15- to 20-year period, (3) treatment and land disposal in the forest or (4) treatment and reuse for crop irrigation.

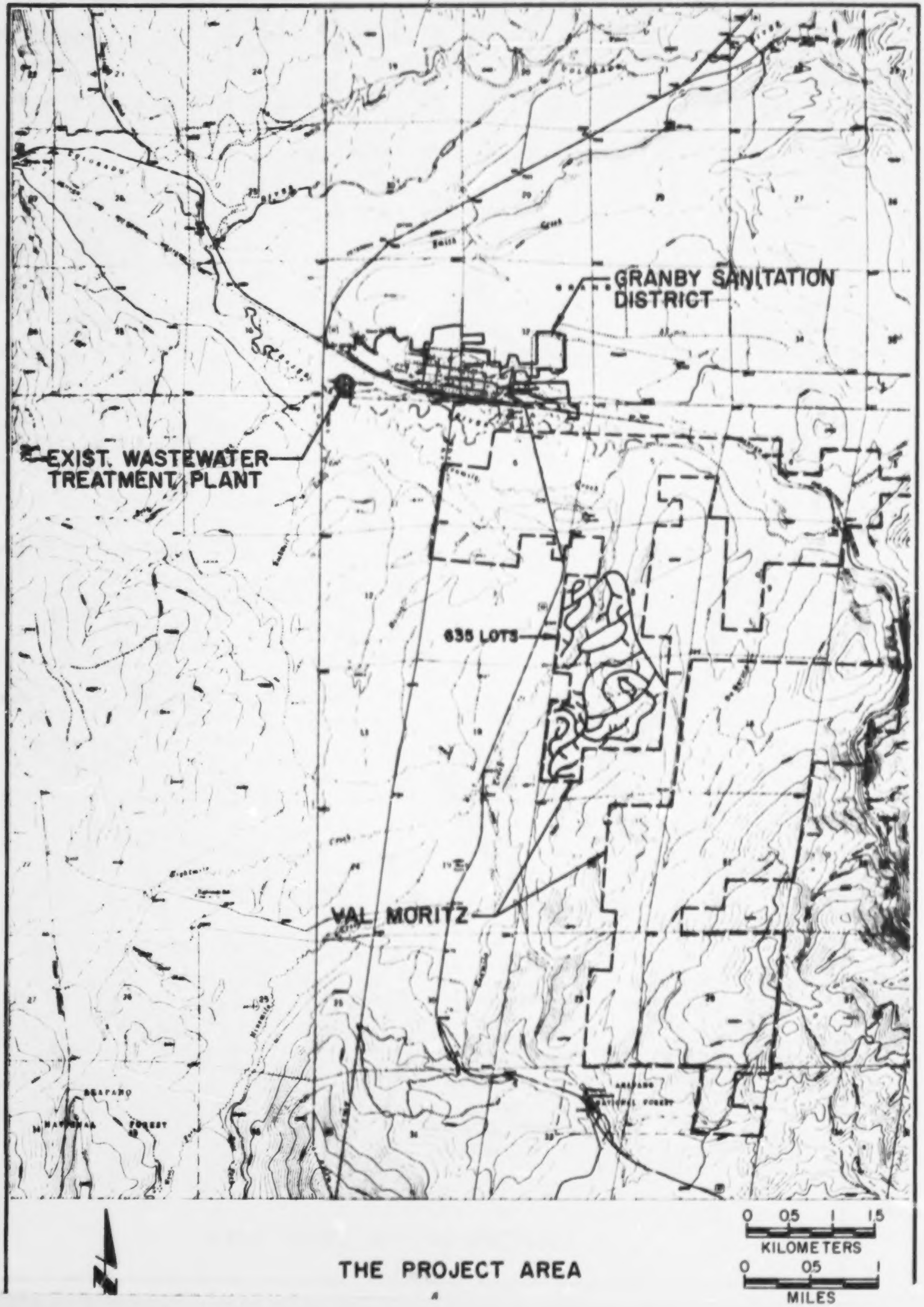
The size of the proposed facility is based upon population projections of up to 17,000 users in 1990. The major portion of this projected growth is to be contributed by a proposed large-scale residential and recreational development (Val Moritz) southeast of Granby. The realization of an almost 11-fold increase in population in the next 15 years is dependent upon many external factors and in fact may not occur. The speculative nature of the proposed development makes population and flow projections highly uncertain.

FIGURE 1


DESIGNATED FACILITIES PLANNING AREA
DENVER
COLORADO
JACKSON
LARIMER
CONTINENTAL DIVIDE
DESIGNATED FACILITIES PLANNING AREA
GRANBY
BOULDER
BOULDER
GRANBY QUADRANGLE
GRAND COUNTY
GILPIN
MIDDLE PARK
CLEAR CREEK
LAKEWOOD
DENVER
Commerce City
SUMMIT
JEFFERSON
DOUGLAS
LAKE
PARK
0
10
20
30
KILOMETERS
0
10
20
MILES

LOCATION OF THE STUDY AREA

FIGURE 2


GRANBY SANITATION DISTRICT
EXIST. WASTEWATER TREATMENT PLANT
635 LOTS
VAL MORITZ
0 0.5 1 1.5
KILOMETERS
0 0.5 1
MILES

THE PROJECT AREA

The new, expanded wastewater treatment facilities will replace the existing plant, which serves some 600 permanent residents and about 1,000 visitors in the Granby area. The existing plant has undergone numerous changes and is no longer suitable for further expansion in capacity or upgrading in treatment processes. The new facilities are expected to serve the future waste treatment and disposal needs of the District residents as well as those of the homes to be built at the now-inactive Val Moritz Development Company tracts. Future sewerage needs of the planning area are largely dependent upon the rate of home-buying and building that may occur beyond the spring of 1976, after (or if) Val Moritz resumes sales efforts and starts utilities construction.

Over the past few years, the growth rate for second homes has fallen far short of early projections made by the developers, with the result that sales activities have recently been suspended. However, the size and type of treatment works recommended in the Facilities Plan were based on those early projections. Insofar as this Draft Environmental Impact Statement is concerned, more than one alternative course of action remains feasible for the Granby Sanitation District to pursue, although the engineering, economic and environmental evaluations of alternatives tend to indicate the desirability of the phased construction of a wastewater treatment plant.

## Environmental Goals, Constrainsts and Regulations

The principal goal is the protection of the natural environment and the quality of life which is associated with it in these high mountain areas. Some of the constraints existing in the Granby area are imposed by the natural geographical setting whereas others are defined by laws, court precedents and regulatory actions. Recognition of these constraining circumstances helps in evaluating the environmental impacts of a proposed new project in this setting.

(1) Very cold winters in the Granby area impose a limit on the ability of biological processes to effect wastewater treatment.

(2) Highly popular stream fisheries of excellent quality attract sports fishers from afar.

(3) Complicated water rights conditions make any significant change in the disposition of the final effluent difficult to accomplish, subject to various technical and legal procedures.

(4) The Fraser River is classified as a "water quality-limited" stream by the Colorado State Department of Health.

(5) The Colorado River Basin Water Quality Management Plan of 1975 imposed specific effluent limitations on ammonia (6.8 kg/day [15 lb/day] in summer and 50.3 kg/day [111 lb/day] in winter) and residual chlorine (0.077 kg/day [0.17 lb/day] year round) on discharges to Fraser River in the Granby Area.

(6) The proposed Windy Gap project may impose even more stringent nutrient concentration limits on Granby discharge to Fraser River for the protection of water quality in the Big Thompson (Three Lakes) system.

## The EIS Process

The U. S. Environmental Protection Agency has determined that the proposed Granby Wastewater Treatment Facility is a major project with significant environmental effects. EPA is required by law to prepare an Environmental Impact Statement on such projects. This requirement is pursuant to Section 102(2)(c) of the National Environmental Policy Act of 1969, its amendments and the case law ensuing therefrom.

The EPA is preparing this environmental impact statement as documentation of (1) the analysis and deliberation of the environmental and quality-of-life impacts of its possible funding of the proposed wastewater treatment system, (2) the full consideration of the possible courses of action which could be followed to meet and maintain Federal and State water quality standards as related to the Granby Sanitation District, (3) the decision-making process by EPA on its course of action at Granby and (4) the involvement of other agencies and the citizenry in this process. The final EIS will serve as a statement of EPA's course of action on the Granby Sanitation District's proposed action.

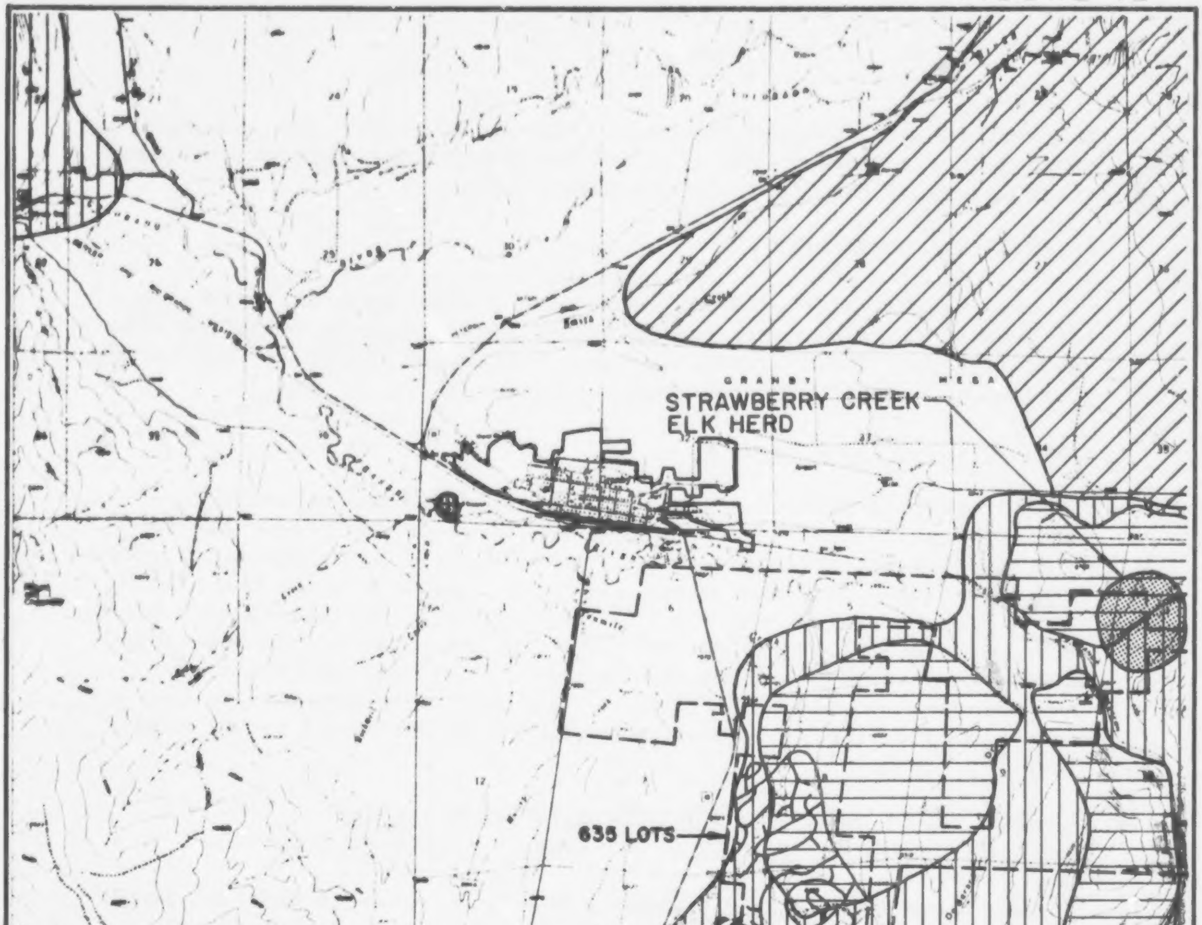
## THE ENVIRONMENT

Granby and the Granby Sanitation District are located in a high mountain valley known as Middle Park and are surrounded by various ranges of the north-central Colorado segment of the Rocky Mountains. The area is characterized by a short growing season, severe climatic conditions, high mountains, irrigated river valleys and extensive forest lands. The natural beauty of the area, its proximity to Rocky Mountain National Park and to other extensive public lands managed by the U. S. Forest Service, its accessibility to several major ski areas and its location on a major Federal highway result in a large and growing use and visitation of the area by vacationers and recreationists. In fact, it is these very amenity and locational factors which have resulted in substantial growth and development pressure on the planning area. Ironically, this very growth and development, unless adequately controlled, could severely damage the very values which made the area attractive in the first place.

Of particular importance in the natural environment of Granby are the wildlife habitats in the southeastern part of the planning area. Critical winter range areas for deer and elk have been identified by Colorado wildlife officials at locations coinciding with plans for development of relatively high-density residential areas, as shown in Figure 12.

An important and unique feature of the planning area is its situation near the headwaters of the Colorado River System. Also of importance to the Granby area and to those who use it are the quality fisheries of the Fraser and Colorado Rivers. Protection of these fishery resources is a priority element of environmental planning for the area.

FIGURE 12


STRAWBERRY CREEK ELK HERD
GRANBY MESA
635 LOTS
RED DIRT HILL DEER MIGRATION ROUTE
ARAPAHO NATIONAL FOREST
LEGEND
DEER - GENERAL WINTER RANGE
DEER - CRITICAL WINTER RANGE
ELK - CRITICAL WINTER RANGE
EXISTING WASTEWATER TREATMENT PLANT SITE
BOUNDARY OF GRANBY SANITATION DISTRICT
BOUNDARY OF VAL MORITZ RESIDENTIAL DEVELOPMENT
SOURCE: COLORADO STATE UNIVERSITY (REFERENCE 27)
0 0.5 1 1.5
KILOMETERS
0 0.5 1
MILES

SENSITIVE WILDLIFE AREAS

The implications of these important features *vis-a-vis* the wastewater management practices in the area and their potential impacts upon downstream users of the river are considered here.

## ALTERNATIVES CONSIDERED

Six feasible alternatives, comprising a wide range of choices for the people of Granby, were evaluated for environmental, social and economic impacts. These alternatives are summarized below, and the location of certain features are presented in Figure 10.

### Alternative 1 - No Action

The existing secondary level of wastewater treatment would be maintained and discharge of effluent continued to the Fraser River. No attempts would be made to expand service for future population growth. This alternative currently meets discharge standards, with the exception of the total residual chlorine requirement. The plant, with minor modifications, will be adequate to service the needs of the most conservatively estimated future populations to 1995 but would not meet the stringent ammonia mass-emission requirements recommended in the basin plan and likely to be included in future discharge permit conditions for Granby.

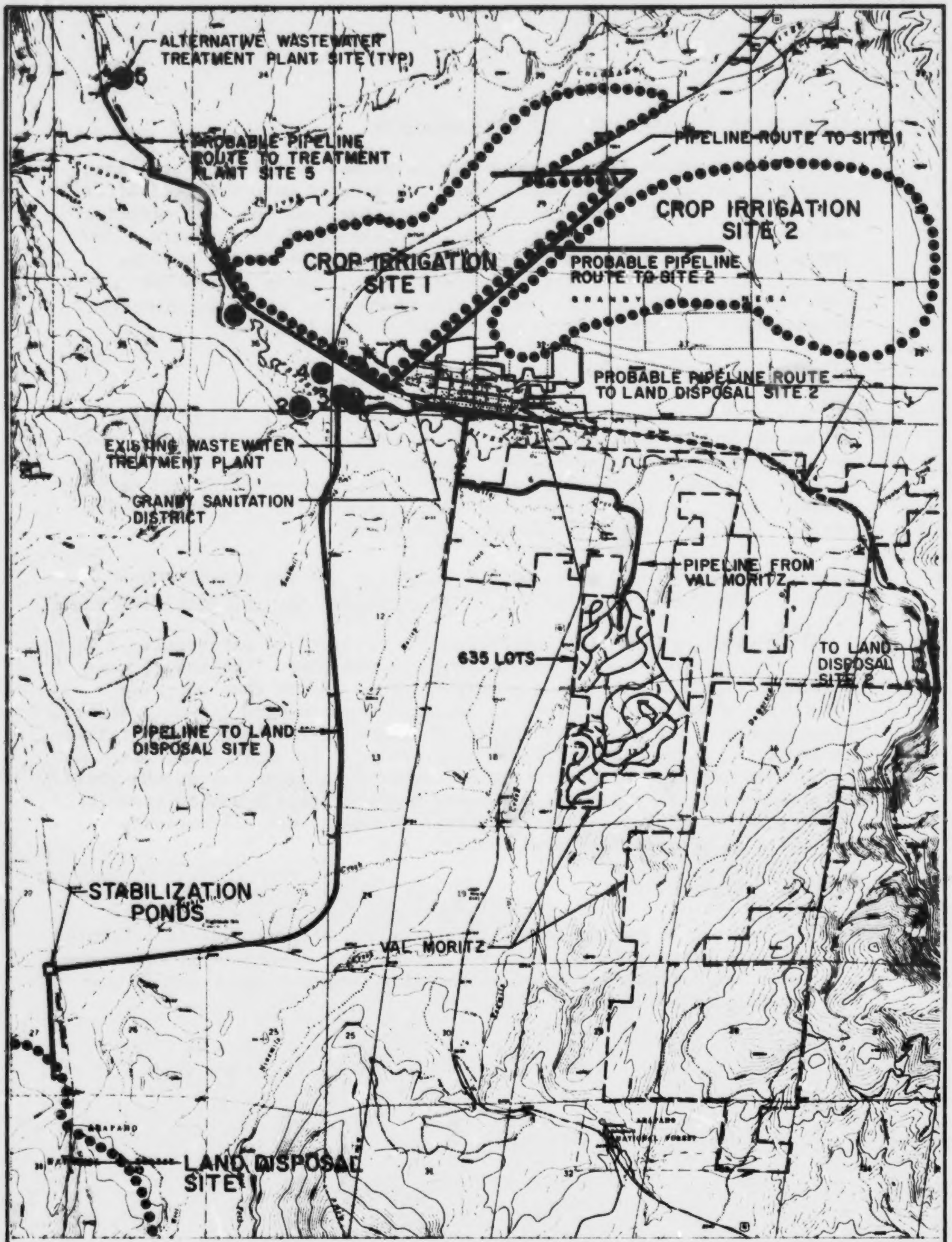
### Alternative 2 - Construction of New 5,700 cu m per day [1.5 mgd] Treatment Plant with Discharge to Fraser River

This alternative would provide a new 5,700 cu m per day [1.5 mgd] biological, secondary-level treatment facility with provisions for nitrification of the effluent. The facility would be near the site of the existing plant, and its effluent would be discharged to the Fraser River. Excepting the no-action alternative, this alternative has the lowest capital construction cost and next to the lowest annual operation and maintenance cost, assuming that the maximum projected growth materializes.

### Alternative 3 - Construction of New 5,700 cu m per day [1.5 mgd] Treatment Plant with Discharge to Colorado River

Although treatment levels would be essentially the same as those in the previous alternative, the higher dilution capacity of the Colorado River would make the effluent quality restrictions necessary to meet water quality standards less severe. Longer wastewater transport distances, to the treatment site along Highway 125 north of Highway 40 and to the Colorado River, make this alternative more costly than the second alternative. For economic comparison with the above alternative, this facility was analyzed assuming maximum population growth conditions.

FIGURE 10


ALTERNATIVE WASTEWATER TREATMENT PLANT SITE (TYP)
5
PROBABLE PIPELINE ROUTE TO TREATMENT PLANT SITE 5
PIPELINE ROUTE TO SITE 1
CROP IRRIGATION SITE 2
CROP IRRIGATION SITE 1
PROBABLE PIPELINE ROUTE TO SITE 2
GRANBY
MESA
1
4
2
3
PROBABLE PIPELINE ROUTE TO LAND DISPOSAL SITE 2
EXISTING WASTEWATER TREATMENT PLANT
GRANBY SANITATION DISTRICT
PIPELINE FROM VAL MORITZ
635 LOTS
TO LAND DISPOSAL SITE 2
PIPELINE TO LAND DISPOSAL SITE 1
STABILIZATION PONDS
VAL MORITZ
LAND DISPOSAL SITE 1
ARAPAHO NATIONAL FOREST
0
0.5
1
1.5
KILOMETERS
0
0.5
1
MILES

ALTERNATIVE TREATMENT PLANT SITES, ALTERNATIVE PIPELINE ROUTES AND POTENTIAL LOCATIONS FOR CROP IRRIGATION WITH EFFLUENTS S. 9

### Alternative 4 - Treatment and Land Disposal

Raw wastewaters from Granby would be pumped to a lagoon treatment system in the Arapaho National Forest and sprayed onto the land after treatment. Land disposal requirements are low, and the less efficient but also less costly lagoon treatment process would be adequate. However, the short summer season necessitates large ponds for storing the effluent during the winter, a costly item. Spray irrigation systems also have high capital cost. Groundwater pollution and nitrogen accumulation are potential problems but can be mitigated.

### Alternative 5 - Treatment and Crop Irrigation

Raw wastewaters would be treated in lagoons on the Granby Mesa. During the summer growing season, chlorinated secondary-level effluent would be sprayed onto hay fields. Again, winter storage costs would be high, but savings could be realized in the low operation and maintenance costs. A significant cost reduction would be effected if the need for lining the lagoon could be eliminated.

### Alternative 6 - Staged construction of any of the above-mentioned treatment works in three 1,900 cu m per day [0.5 mgd] capacity increments.

To provide an example, the facilities involved in Alternative 2 were analized for staged construction. It was found that staged construction of facilities is only slightly more costly than one-time construction and that compared to unstaged construction it would afford tremendous savings to the residents of Granby in case Val Moritz failed to develop: if the larger (5,700 cu m per day [1.5 mgd]) plant were to be constructed and Val Moritz did not develop, a large tax burden would be placed upon the residents of Granby for the largely wasted capacity of an under-used plant. Alternatives 2 through 5 are all amenable in differing degrees to staged construction.

## COSTS OF ALTERNATIVES

The summary comparison of costs of the six alternatives is presented in Table 1. Costs under Alternative 2 through 5 are based on the assumption that Val Moritz does develop, and Alternative 6 costs assume that Val Moritz does not develop.

## TABLE 1

## SUMMARY COMPARISON COSTS FOR ALTERNATIVES 2 THROUGH 6

| COST FACTOR | ALTERNATIVE 2 FRASER RIVER DISCHARGE | ALTERNATIVE 3 COLORADO RIVER DISCHARGE | ALTERNATIVE 4 FOREST LAND APPLICATION | ALTERNATIVE 5 IRRIGATED FARM LAND APPLICATION | ALTERNATIVE 6 STAGED CONSTRUCTION |
|---|---|---|---|---|---|
| Capital cost | | | | | |
| Total | 2,564,500 | 3,703,500 | 4,140,000 | 3,000,000 | 1,332,500 |
| Land | 35,000 | 35,000 | 0 | 175,000 | 35,000 |
| Local share | 540,900 | 768,700 | 828,000 | 740,000 | 294,500 |
| O & M at full operation | 80,000 | 95,000 | 110,000 | 65,000 | 50,000 |
| Present worth[a] | 2,865,100 | 3,955,600 | 4,484,400 | 2,984,000 | 1,569,520 |
| Average annual equivalent cost | 380,000 | 520,100 | 598,600 | 392,300 | 206,000 |

[a] Present worth = capital cost plus present value of O & M costs over 15 years discounted at 10 percent minus present worth of salvage value in 15 years (also discounted at 10 percent), where salvage value equals 1/2 (assuming 30-year life) of initial capital cost (excluding land and Facilities Plan) plus land cost.

## ENVIRONMENTAL IMPACTS OF PROPOSED ACTION

The major beneficial and adverse environmental impacts of all alternatives considered are presented on a matrix in Figure 5, and are summarized below:

### Alternative 1 (No action)

The existing wastewater treatment plant will continue to contribute ammonia-nitrogen and residual chlorine to the Fraser River. This facility will probably not be able to meet future discharge permit conditions which reflect both State and Federal requirements based on Basin Plan recommendations with respect to ammonia and residual chlorine effluent limitations and total suspended solids and biochemical oxygen demand percent removals. Continuation of the present level of treatment and discharge could lead to potential toxic summer concentrations of ammonia-nitrogen in the Fraser River and could cause summer fish kills and overall reduction in benthic productivity. The nitrogen contribution would also have a seasonal stimulatory effect upon algal growth. Reduced water quality in the Fraser River would also have a negative impact on the river as a recreational resource.

Adoption of a no-action course could lead to the formation of a separate sanitation district for Val Moritz if Val Moritz does develop. Such a district would probably use either package plants or septic tanks. In case of reliance on septic tanks, the minimum one-hectare [2-acre] lot size required by Grand County would necessarily lead to a redesign of Val Moritz's subdivision plans. Septic tanks generally contribute to groundwater pollution, and package plants tend to be unreliable in nearly all situations.

Unavailability of excess sewerage capacity would discourage residential and commercial developments from encroaching on this high mountain valley and thereby help it to retain its natural aesthetic environment and critical wildlife habitats.

### Alternatives 2 through 6

#### Construction Impacts--

Construction activities resulting from the implementation of Alternatives 2, 3, 4, 5 or 6 will cause short-term erosion and downstream sedimentation. Turbidity and sedimentation effects on the aquatic environment would be short term in nature, and physical stream conditions would be restored by the natural scouring action of the spring flows. Staged construction (Alternative 6) would partially spread this damage over a longer period of time and permit regrowth of vegetation between stages.

Alternatives 2, 3, 4 and 5 will require employment of up to 50

## Figure 5. SCHEMATIC REPRESENTATION OF RELATIVE SEVERITY AND DIRECTION OF OPERATIONAL AND SECONDARY IMPACTS OF VARIOUS WASTEWATER MANAGEMENT ALTERNATIVES FOR GRANBY SANITATION DISTRICT, COLORADO

| | Alternative no. | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | | 2 | | 3 | | 4 | | 5 | | 6 | |
| | No action | | New 5,700 cu m/day plant, discharge to Fraser River | | New plant, discharge to Colorado River | | Lagoon treatment and land disposal | | Lagoon treatment and crop irrigation | | Staged construction in three 1,900 cu m/day increments | |
| Environmental parameter | Operational | Secondary | Operational | Secondary | Operational | Secondary | Operational | Secondary | Operational | Secondary | Operational | Secondary |
| Growth inducement | ◦ | · | ⬤ | · | a | a | a | a | a | a | • | · |
| Soils | · | · | · | ● | · | a | · | a | · | a | · | • |
| Landforms | · | · | · | ⬤ | · | a | • | a | • | a | · | • |
| Surface water: Quantity | · | · | · | · | · | a | • | a | • | a | · | · |
| Legal implications | · | · | · | · | · | a | ⬤ | a | ⬤ | a | · | · |
| Quality | • | · | ○ | • | ○ | a | ◯ | a | ◯ | a | ○ | • |
| Groundwater quality | · | · | · | · | a | a | • | a | • | a | · | · |
| Flora | · | · | · | ● | · | a | ◦ | a | ○ | a | · | • |
| Fauna | ● | · | ○ | ⬤ | ○ | a | ● | a | ● | a | ○ | ● |
| Air quality | · | · | · | ● | · | a | • | a | • | a | · | • |
| Noise | · | · | · | ● | · | a | · | a | · | a | · | • |
| Odor | • | · | · | · | · | a | • | a | • | a | · | · |
| Severage service costs with Val Moritz | · | · | • | NA | a | a | a | a | a | a | • | NA |
| Severage service costs without Val Moritz | · | · | ⬤ | NA | a | a | a | a | a | a | • | NA |
| Employment potential | · | · | ◦ | ○ | ◦ | a | ◦ | a | ◦ | a | ◦ | ◦ |
| Public health | • | · | ◦ | · | ◦ | a | ◦ | a | ◦ | a | ◦ | · |
| Recreation | • | · | ◦ | ◦ | ◦ | a | ◦ | a | ◦ | a | ◦ | ◦ |
| Aesthetics | · | · | • | ⬤ | • | a | ● | a | ● | a | • | • |
| Natural resources | · | · | · | ⬤ | · | a | ◯ | a | ◯ | a | · | • |
| Traffic | · | · | · | • | · | a | · | a | · | a | · | • |

[a] The main purpose of including these alternatives in the analysis is evaluation of different discharge locations and treatment/disposal processes. Their secondary impacts would depend on whether they were constructed in stages or at once, either of which is possible for each alternative.

| Legend: | Major | Moderate | Minor | None |
|---|---|---|---|---|
| Positive (Beneficial) | ◯ | ○ | ◦ | · |
| Negative (Adverse) | ⬤ | ● | • | · |

construction-related workers. The local construction labor force is not adequate to meet this need, and it may be necessary to import up to half the needed work force. Alternative 6 may require less imported labor for the first phase, with this impact from the next two phases being dependent on the state of the economy.

Additional construction impacts for individual alternatives are summarized below.

Alternative 2 (New 5,700 cu m/day [1.5mgd] Plant, Fraser River Discharge) -- Sewage treatment plant construction would involve the removal of some riparian vegetation. Because of the proximity of this site to Highway 40, visual quality would be impaired by excessive removal of vegetation, particularly the willow trees and willow shrubs.

Dust raised during site preparation and engine emissions from construction equipment - largely devoid of air pollution emission controls - will have a negative impact on air quality during a maximum period of about three months. Increased noise levels audible to local residents will also occur during the construction phase.

Alternative 3 (New 5,700 cu m per day [1.5 mgd] Plant with Colorado River Discharge) -- Because the treatment plant site is situated in a sagebrush community with low soil moisture, revegetation of the site may be rather slow without additional seeding and irrigation. The treatment plant would be visually exposed on the open hillside because of the absence of natural vegetation screens, although its location in a remote and unpopulated area largely mitigates this impact.

Dust raised during site preparation and engine emissions from construction equipment - largely devoid of air pollution emission controls - will have a negative impact on air quality during a maximum period of about three months. Increased noise levels audible to local residents will also occur during the construction phase.

Alternative 4 (Treatment and Land Disposal) -- The construction impacts of Alternative 4 are not confined to the land disposal site alone but include the length of the 9.1-km [5.8-mile] pipeline route as well. Pipeline construction would have short-term adverse effects on the sagebrush inhabitants, particularly ground squirrels.

The removal of 24 to 32 hectares [60 to 80 acres] of sagebrush and grassland for the stabilization ponds will have a permanent site-specific effect on vegetation and represent an irreparable loss of wildlife habitat. The effect will be particularly noticeable since the ponds bordering the forest will eliminate the existing forest-sagebrush "edge" habitat. Animal species intolerant to human presence would probably migrate to adjacent areas. If the adjacent areas are already stocked to capacity, the migrations will result in ultimate reduction in animal populations.

Short term air pollution contributions can be expected from the construction of the pipelines as well as from the excavation of effluent storage reservoirs.

Alternative 5 (Treatment and Crop Irrigation) -- The construction impacts of Alternative 5 will be mainly in the Grassland-Agriculture unit of the Granby Mesa area. The pasture and rangeland activities will be temporarily disrupted during construction.

The removal of 24 to 32 hectares [60 to 80 acres] of grassland and sagebrush for the stabilization ponds will have a permanent site-specific effect on vegetation and represent an irreparable loss of wildlife habitat. The granby Mesa rangelands are fairly extensive, and the stabilization pond site would actually consume a very small percentage of the total habitat. Construction of the ponds would have less impact than in Alternative 4 as the local habitat is primarily grassland without any distinct "edge" environments. The upper mesa area, however, does serve as critical elk winter range. If construction is completed prior to the winter season, elk patterns should not be affected.

Short term air pollution contributions can be expected from the construction of the pipelines as well as from the excavation of effluent storage reservoirs.

Alternative 6 (Staged construction)-- The initial construction impacts would probably be equal to those of Alternative 2. In successive years, as further construction is needed, impacts would be negligible. Plant enlargement would be within the confines of the developed site and should have much less impact than the original construction.

Operational Impacts--

The implementation of new wastewater treatment works will have an effect on the local tax structure, with probable increases in property tax for Granby residents, unless the project is constructed in stages, as needed (Alternative 6). This effect will be particularly severe in Alternatives 2 and 3 if Val Moritz fails to develop to the extent and at the rates projected.

Unless recommended mitigative measures are incorporated into the design of the treatment processes, any treatment plant will emit the following: (1) septic odors from the influent pump station wet well and primary clarifiers, (2) characteristic odors from Biodisc or activated sludge units, (3) sulfur odors from anaerobic sludge digestor gases, and (4) odors generated in the sludge drying beds. As flow into the plant increases, the severity of, and resultant annoyance from, the bad odors will increase.

Alternatives 2 through 6 anticipate the development of Val Moritz. If this occurs, property values in Granby may rise in response. If

Val Moritz does not develop, property values will not rise, in the absence of other, yet undetermined, growth pressures.

Improved water quality will have beneficial impacts on recreational activities and surface water resources associated with the Fraser and Colorado Rivers.

Additional operational impacts for individual alternatives are summarized below.

Alternative 2 (New 5,700 cu m per day [1.5 mgd Plant, Fraser River Discharge) -- Alternative 2 was designed to meet the water quality standards with a greatly increased wastewater flow rate. Biochemical oxygen demand loading and nutrient loading to the Fraser River will increase but, because of high reaeration, will not significantly deplete the dissolved oxygen. The total amount of ammonia discharged from the ultimate flow after ammonia removal will need to be less than that being discharged by the present Granby treatment plant.

The increase in total stream pollutants resulting from the increased volume of effluent discharged will have a long-term selection effect favoring pollutant-tolerant aquatic species.

Alternative 2 would have a slightly negative impact on local aesthetic qualities, although the preferred site, adjacent to the present facility, would cause little visual impact.

Alternative 3 (Colorado River Discharge) -- Alternative 3 will be superior to Alternative 2 from a water quality viewpoint because the effluent will be discharged to the Colorado River, where the higher flows will enhance dilution. Alternative 3 will also meet the existing water quality standards.

The increase in total stream pollutants resulting from the increased volume of effluent discharged will have a long-term selection effect favoring pollutant-tolerant aquatic species.

Because of the remoteness of the plant site in Alternative 3, the potential for its odors to reach annoyance proportions in Granby will be less than under the other alternatives.

The proposed site, although the least conspicuous of the considered sites, would introduce construction where there is none at the present time and there would be a minor negative impact on the aesthetic character of the area.

Alternative 4 (Treatment and Land Disposal) -- The storage ponds will cause gradual clogging of soil pores and reduction in soil permeability at the pond sites if the ponds are unlined. The soil structure will be deteriorated and may require special amendments and cultural practices for future reclamation.

The spray sites will experience a gradual increase in soil organic matter content over several years, a distinctly beneficial impact. The nutrients in wastewater effluent will enrich soil productivity, and the heavy metals (presumably very low in the Granby wastewaters) will have a rather minor negative impact over an extended period (more than 20 years) of application.

Removal of sewer effluent discharges from the Fraser River would have a limited to negligible effect on water quantity and aquatic habitat because of the relatively small amount of water involved. Certain legal problems may arise concerning the water rights of downstream senior appropriators. The expenditure of considerable time and resources may be necessary to resolve these problems.

Alternative 4 will have a beneficial effect on surface water quality by altogether removing wasteloads from the Fraser River. Long-term irrigation may lead to the accumulation of nitrates in groundwater and materials which may decrease soil productivity.

Forest irrigation will lead to a shift in the existing lodgepole pine ecosystem by favoring the growth of more water-tolerant species along with lodgepole pine. Passing migrant waterfowl will be attracted to additional water areas created by the aerated waste stabilization ponds.

Elk and deer winter areas and fall migrations will be disturbed as a result of construction and operational activities. Site 2 is near the Strawberry Creek area, which is an important elk and deer range. Deer may be slightly more disrupted, as their migrations begin in the early fall, while elk generally remain in the high country until the first snowfall.

Excess runoff may occur in certain areas. Erosion may be increased due to lack of the significant understory that is characteristic of lodgepole pine forests. Site 2 is near three watercourses which could receive effluent and sediment in runoff.

Odors may develop in the stabilization ponds resulting from biological processes occurring in any free body of water with biostimulants (nitrogen, phosphorus, sunlight) in abundant quantities. Thus, nuisance conditions may be expected, especially if ponds are allowed to become anaerobic. This condition will occur in wintertime when ponds are covered with ice. The spring thaw usually involves a few days of severe odor problem.

Spraying effluent will produce aerosols containing microorganisms and the dissolved solids present in the effluent. These aerosols can be carried by wind to areas downwind of the spray areas.

Alternative 4 could cause a significant negative aesthetic impact. Pipeline construction through range and forest land would substantially alter the appearance of the route for a period of years. The required access road to the waste stabilization ponds and the ponds themselves would seriously degrade the existing character of the land.

Alternative 5 - Treatment and Crop Irrigation -- The storage ponds will cause gradual clogging of soil pores and reduction in soil permeability at the pond sites if the ponds are unlined. This change can be viewed as a beneficial impact from the point of view of conserving the water resource for irrigation and in protecting groundwater supplies. However, the soil structure will be deteriorated and may require special amendments and cultural practices for reclamation in the future.

The spray sites will experience a gradual increase in soil organic matter content over several years, a distinctly beneficial impact. The nutrients in wastewater effluent will enrich soil productivity, and the heavy metals (presumably very low in the Granby wastewaters) will have a rather minor negative impact over an extended period (more than 20 years) of application.

Removal of sewer effluent discharges from the Fraser River would have a limited to negligible effect on water quantity and aquatic habitat because of the relatively small amount of water involved. Certain legal problems may arise concerning the water rights of downstream senior appropriators. The expenditure of considerable time and resources may be necessary to resolve these problems.

Alternative 5 will have a beneficial effect on surface water quality by removing wasteloads from the Fraser River. Irrigation enhances the productivity and feasibility of agriculture on the Granby Mesa area, although that short growing season limits agricultural activities. Groundwater pollution may occur if proper site selection and application techniques are not followed. Heavy metals, bacteria and viruses from effluent can enter the ecosystem and food chain, but this impact is not expected to be of significant proportions in Granby.

If irrigation systems are conducted such that they pose barriers to elk movement, this alternative will have a negative impact on their critical winter range. However, since most irrigation will be conducted in seasons other than winter, the impact will be minimal.

Odors may develop in the stabilization ponds resulting from biological processes occurring in any free body of water with biostimulants (nitrogen, phosphorus, sunlight) in abundant quantities. Thus, nuisance conditions may be expected, especially if ponds are allowed to become anaerobic. This condition will occur in wintertime when ponds are covered with ice. The spring thaw usually involves a few days of severe odor problem.

Spraying effluent in crop irrigation will produce aerosols containing microorganisms and the dissolved solids present in the effluent. These aerosols can be carried by wind to areas downwind of the spray areas; this dispersal of aerosols can be particularly significant in the Granby Mesa, with its high elevation in comparison with surrounding areas and its exposure to winds from Windy Gap.

Alternative 5 would affect the aesthetic qualities of the area less than Alternative 4, and some degradation of the aesthetic environment would result from the pipeline and pond construction.

Alternative 6 (Staged construction) -- Alternative 6 is a staged development plan and, with the exception of possibly smaller sewage flow (due to fewer growth-inducing effects), the water quality impacts will be similar to those of Alternative 2. An important advantage of Alternative 6 is the benefit of testing the operation of the facility and its ability to nitrify the effluent under cold-water conditions without investing in a larger facility that may not be capable of meeting the permit conditions.

The increase in total stream pollutants resulting from the increased volume of effluent discharged will have a long-term selection effect favoring pollutant-tolerant aquatic species.

If Val Moritz fails to develop to the extent and at the rates projected, Granby residents will not be burdened by the costs of a larger treatment plant (Alternatives 2 and 3).

Alternative 6 would have a slightly negative impact on local aesthetic qualities, although the preferred site, adjacent to the present facility, would cause little visual impact.

Growth Inducing Impacts --

The growth-inducing impacts of the proposed project may be affected by the phasing of construction. There appears to be no economic justification for immediate construction of a 5700 cu m/day [1.5 mgd] facility at this time. A 1900 cu m/day [0.5 mgd] facility would appear to be adequate to meet all projected needs through the mid-1980's.

If the full 5700 cu m/day [1.5 mgd] facility were built, one effect would be to increase significantly the pressures for additional growth in the service area. The substantially higher operating and debt service costs associated with development of a plant with at least 3800 cu m/day [1 mgd] initial excess capacity would create pressures on the District and its customers to encourage rapid expansion of the customer base as quickly as possible, to offset the adverse effects on user charges and taxes. This pressure could manifest itself in the encouragement of more rapid development at Val Moritz or the soliciation of additional second-home development in the area. Local residents could find it harder to maintain an independent and unbiased attitude toward additional growth in face of these additional municipal service costs.

Although the existing wastewater treatment plant is nearing capacity, the present facility has a severe infiltration problem, accounting for perhaps 1140 cu m/day [0.3 mgd] during peak snow melt and irrigation seasons. The correction of this problem, which can be accomplished without the construction of a new treatment plant, or alternatively, the construction of only the first phase of the proposed project with a capacity of 1900 cu m/day [0.5 mgd] would provide adequate growth capacity for all anticipated local (endogenous) growth.

It would appear that except for Val Moritz, external growth factors affecting the Granby Sanitation District service area are not likely to produce significant changes in projected local growth. Population increases of perhaps 100-300 over the next five or ten years might be reasonably attributed to such a factor, but they would not materially change the local population characteristics nor would they materially increase the need for wastewater treatment facilities.

The best available current indicators suggest that without the proposed project in one form or another, Val Moritz will not be able to complete its proposed development. Therefore, it appears that the growth-inducing impacts of Val Moritz are related to the proposed project.

Original population growth projections in the Facilities Plan and the Water Quality Management Plan were based on the apparently successful sales program that Val Moritz had experienced in 1974. The scope and size of the proposed wastewater treatment plant in the Facilities Plan was predicated on continuing sales and development, culminating in an estimated population of 17,000 in 1990. However, sales were subsequently halted, and while they are scheduled to resume in 1976, there is a great deal of uncertainty as to future events.

Two new growth projections were made: a base projection of 9,700 by 1990, and a reduced projection of 7,100 by 1990. Assuming that this growth, primarily by Val Moritz residents, is only possible because of an enlarged wastewater facility, the growth induced by the proposed project will be approximately 8000 people (under the base projection) or 5400 people (under the reduced projection). Most of these growth inducing impacts would be felt in the ten-year period between 1980 and 1990, since the effects through 1980 would be relatively modest because of the slow build-up anticipated for Val Moritz.

Secondary Impacts --

Secondary impacts are those impacts which result from growth that is induced by the proposed project. If the proposed project leads to an increased population in the Granby area, the following secondary impacts are expected to occur:

Most of the soils in the planning area are readily erodible and severly limited insofar as their "community development" capability is concerned. Placement of residential communities on such soils can produce damaging quantities of erosion and sedimentation downstream in addition to the unsightliness of eroded areas. Potential slope failures and foundation problems may endanger life and property unless extensive borings and sophisticated foundation analyses are made and proper footings are provided, particularly for the larger structures such as multifamily dwellings, hotels and commercial areas.

All alternatives will have similar potential for secondary water quality impacts. Additional residential development in the Granby area will cause some pollution due to nonpoint sources of runoff. Erosion from unpaved areas and cut and filled slopes during construction of the development (until vegetation takes hold) will cause some sediment to be discharged into the streams; however, measures can be employed to reduce these effects. Generally then, secondary impacts upon water quality will be amenable to mitigation with proper design of the conveyance structures and treatment of runoff. It is very important that regulatory controls be established, implemented and rigorously enforced so that the necessary mitigative measures are actually designed and built into the developments that are permitted.

Future development activity will remove land areas from the open spaces of the Granby region. Subdivision and development cause a general decrease in visual and aesthetic quality by the creation of buildings and structures in former open and undisturbed areas.

The Granby Mesa area and south-facing slopes are important wildlife wintering areas. The future development of Val Moritz will have a significant impact on the critical deer and elk wintering range. The approved 635 lot subdivision of "Innsbruck" falls completely within general deer winter range. Approximately one-third of the building area would occupy the *critical* deer winter range near Tenmile Creek. The remaining Val Moritz property almost completely surrounds this critical deer area on BLM land, and encroaches upon the critical deer and elk areas near Strawberry Creek. The human occupation and disturbance of critical wintering areas may have a profound effect on wildlife. Loss of wildlife habitat because of the reduction of food and shelter available to wildlife as well as increased population density is a long-term secondary impact.

Off-road vehicles, such as motorbikes, four-wheel drive vehicles and snowmobiles, can cause destruction of vegetation, soil compaction, soil erosion, noise and disruption of wildlife habitat.

There are other impacts associated with growth inducement potential of the wastewater treatment facilities. Secondary impacts on environmental parameters such as air quality, noise and odor can be quite significant. Use of fossil fuels in the periodic movement involved in second-home ownership and the inevitable change from a quiet, rural setting to a gradually more crowded urban life style are other secondary impacts which must be recognized.

## ADVERSE IMPACTS AND RECOMMENDED MITIGATIVE MEASURES

### Soils and Water

Erosion and loss of soil during the construction period, under Alternatives 2 through 6, will be significant adverse impacts. Construction of residential facilities, made possible with the availability of sewerage service in the proposed development areas, will have an even greater erosion potential.

Erosion and runoff can be mitigated by the implementation and enforcement of erosion control measures, which include revegetation, hydromulching, chemical mulching and structural stabilization. These measures will also serve to mitigate adverse impacts on surface water quality during construction activities.

Under Alternatives 4 and 5, pollution of groundwater supplies is an adverse impact of land application of effluents. This impact can be mitigated in large part through proper design of application rates coordinated with actual and potential evapotranspiration and maintained below soil percolation rates.

### Flora and Fauna

Under the no-action Alternative 1, fish toxicity due to ammonia (especially during summer months) and residual chlorine can be expected to continue until future upgrading of the treatment plant is accomplished.

Removal of vegetation associated with Alternatives 2 through 6 will represent an adverse impact that can be partially mitigated by careful retention of as much vegetation as practical and quick revegetation of denuded areas.

The 24 to 32 hectare [60 to 80 acre] stabilization ponds required under both Alternatives 4 and 5 would permanently remove a portion of the wildlife wintering area. Conversion of the existing mixed grassland and sagebrush to monoculture would alter the winter forage supply. Fall harvesting would remove large amounts of potential hay forage as well. The effect upon wildlife would be difficult to ascertain quantitatively; however, a decrease in winter range would alter wildlife feeding patterns and could strongly affect the wildlife carrying capacity and total population.

Although the habitat type would be altered, some agricultural techniques could be utilized to mitigate this impact to the benefit of wildlife. Residual and surplus areas, such as streambanks, road edges, fencerows, corners and woodland patches, when left uncultivated, provide important wildlife habitat. Unharvested strips, stubble and fallow areas would also provide an important supplement.

## Noise

The natural serenity of the mountainous setting of Granby can be threatened with noise produced especially during construction activities. Use of vibratory hammers instead of ordinary pile drivers, where practical, and silencers on compressors and other equipment can help to preserve the quietude of the area.

## Odors

Even the most sophisticated wastewater treatment facilities can emit unpleasant odors if precautions are not taken. Some of the mitigative design features for odor control include (1) scrubbing air from the influent pump station wet-well by pumping it into the aeration basin in the activated sludge process or into oxidizing baths; (2) provision of covers over primary clarifiers, drawing air from under the cover and scrubbing, as above; provision of separate enclosures over the Biodisc units (if such units are used) with scrubbing or ventilation of the air space; (4) use of deodorizing mists downwind of the wastewater treatment plant during periods of particularly bad odor formation or during malfunctions. The latter method is particularly useful for controlling odors from anaerobic sludge digestors.

## Air Quality

Dust control, with the use of dust palliatives, during the construction period can mitigate air pollution from this source.

## Economy

A negative economic impact of the proposed project is its potentially serious effect on property tax rates and/or user charges resulting from slower-than-projected growth and associated decreased annual revenues. Alternatives involving a 5,700 cu m/day [1.5 mgd] plant presume and require large and rapid growth to avoid this impact because the service capacity and the cost of providing and maintaining it are immediate. Any growth induced by the wastewater treatment plant will also have significant economic impacts upon the town of Granby. Alternative 6, the staged expansion service capacity, will permit the increase in capacity and cost to be limited if service demand does not grow as rapidly as originally projected.

### Aesthetics

The construction of a treatment plant and/or pipelines and ponds could have an adverse impact on the aesthetic quality of the area. This impact could be mitigated by careful site selection and by the use of native vegetation for visual screening.

## ADVERSE IMPACTS WHICH CANNOT BE MITIGATED

### Land Forms

The semi-permanent change from dry land to a lake is a drastic impact upon effluent storage areas and is viewed by some as adverse. However, the natural character of the area is such that water bodies do not present a highly atypical setting. Secondary impacts of the availability of sewerage service upon land forms are much more severe and adverse, producing a drastic change from a natural, unbroken mountain landscape to a semi-urban, residential and commercial setting.

### Water

Surface water quality will be temporarily impaired by erosion and runoff resulting from construction activities. Stream conditions will be restored by the natural scouring effects of the spring flow after construction has ceased.

### Fauna

Under Alternatives 4 and 5, where land application would inhibit return of effluent to the stream immediately downstream of Granby, a reduced river flow of a fraction of one percent would be experienced during most periods. During low flow periods, the reduction could be more significant, leading to a slight decrease in aquatic habitat and productivity, particularly during the summer season.

### Odors

Odors formed in the stabilization ponds in Alternatives 4 and 5 cause nuisance conditions which are hard to mitigate. It is the prolific algal blooms and their subsequent decomposition that lead to malodorous conditions in such lakes. Limitations of biostimulants, particularly phosphorus, from the effluent are not easy to accomplish. They involve addition of expensive tertiary treatment chemical units with high cost and commitment of large quantities of chemicals.

### Air Quality

Emissions from construction equipment are adverse air pollution impacts which cannot be mitigated as long as pollution control equipment is not required on these machines by the regulatory agencies. Air quality degradation caused by the secondary impact of induced growth in the area can be considerable.

Resources

Secondary impacts (caused by increased population growth in the area made possible and induced by the new treatment plant, particularly the larger version of Alternatives 2 and 3) implicitly involve gradual loss or deterioration of the following resources:

(1) soils eroded from construction sites,
(2) wildlife habitats covered with residences and commercial activities,
(3) the aesthetic quality of the mountain areas marred by structures built for second-home residences and other activities,
(4) use of fossil fuels in the periodic movement involved in second-home ownership, and
(5) quality of rural life gradually changing toward an urban condition with its concomitant problems.

Land Use

Alternatives 2, 3, 4 and 5 are sized beyond the district's present needs, on the assumption that the growth of Val Moritz would occur as originally projected by the developers. It is already evident that Val Moritz will not grow at that rate. Sales have been suspended since the fall of 1974 and as of March, 1976 have not been resumed.

Future growth of Val Moritz cannot be assumed. If it should not materialize, the revenues needed to meet capital and operating cost could create pressure to permit, or even encourage, development that might otherwise be considered undesirable. Land use planning and the willingness to grant exemptions to existing regulations could thus be influenced by the differing but substantial revenues made necessary by these alternatives.

## IRREVERSIBLE AND IRRETRIEVABLE RESOURCE COMMITMENTS

Two major commitments of resources have been identified with the implementation of wastewater treatment facilities plan: (1) loss of wildlife habitat and (2) commitment of energy and economic resources.

Wildlife Habitat

Alteration and loss of wildlife habitat will be least for the construction of a secondary wastewater treatment plant (Alternatives 2, 3 and 6) and greatest for the land application method (Alternatives 4 and 5).

The secondary impacts of Alternatives 2 through 6 involve growth inducement and its resultant human effects upon the environment. The actualization of the Val Moritz development would cause water quality degradation through erosion and sediment transport, a physical destruction of critical deer winter habitat and a functional deterioration of habitat due to barrier construction, noise, possible dog and cat predation, vegetation changes and human presence.

## Energy and Economic Resources

Alternative 4 will commit the Sanitation District to pumping sewage (10 to 11 km [6 to 7 miles]) to a higher elevation (210 m [700 ft]). Alternative 5 requires a shorter pumping distance and a lesser lift (2 to 16 m [6 to 50 ft]). Both alternatives will require significantly increasing amounts of energy as population (and sewage volume) increases.

Alternative 6 conserves energy most effectively of all the alternatives while still achieving the quality and service goals specified. By not building additional facilities until first-phase 1,900 cu m per day [0.5 mgd] capacity is reached, energy consumption can be kept closer to actual need.

All alternatives except Alternative 1 would make possible increased rates of population growth in the area. The secondary impacts of this growth and development which constitute irreversible and irretrievable commitment of resources are: soil loss from eroded sites, loss of wildlife habitat (some of which is already in critically short supply), permanent loss of the aesthetic quality of the mountain area and commitment of national energy supplies to the periodic and frequent movement involved in second-home ownership.

## SHORT-TERM - LONG-TERM CONSIDERATIONS

The provision of wastewater treatment facilities under any of the alternatives considered, involves uses of the human environment which are, or can be readily made to be, reasonably consistent with the maintenance and enhancement of long-term productivity.

A secondary, related short-term use of environment is the land development activity which is a motivating force behind proposed wastewater treatment plant capacity expansion. It is a short-term use of the environment for those who develop and profit from the land today. It brings long-term waste generation sources to these headwaters of the Colorado River System. The balance between the short-term profitability of land development in these mountain areas and the long-term productivity of the environment lends emphasis to the need for proper land use planning and enforcement.

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# ENVIRONMENTAL IMPACT STATEMENT

on

# WASTEWATER TREATMENT FACILITIES
GRANBY SANITATION DISTRICT
GRANBY, COLORADO

EPA Project No. C-080346

Prepared by

U.S. ENVIRONMENTAL PROTECTION AGENCY
REGION VIII, DENVER

February 1976

Approved By: John A. Green
Regional Administrator

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UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

REGION VIII
1860 LINCOLN STREET
DENVER, COLORADO 80203

Ref: 8W-EE

APR 2 1976

Dear Reader:

A copy of the draft Environmental Impact Statement (EIS) on proposed construction of new sewage treatment facilities for the Granby Sanitation District, Granby, Colorado, is enclosed for your information. Also enclosed is a separate Summary of the EIS which can be read to give you a general overview of the project and its possible impacts.

The Granby Sanitation District submitted a plan to the Environmental Protection Agency which proposed construction of new sewage treatment facilities for the Granby area. This plan, submitted to EPA in May, 1975, recommended a 1.5 MGD (million-gallon-a-day) sewage treatment plant to be located at the present plant site. This size plant would be large enough to handle the sewage treatment needs of some 17,000 people which according to the 1975 plan, were to be in the Granby area by the year 1990. Costs of the plant would be approximately 2.56 million dollars, 75% of which were anticipated to be Federal funds granted by the EPA.

As required by the National Environmental Policy Act, EPA has analyzed the potential environmental, social, and economic impacts of the Granby Sanitation District proposal and written this draft EIS as documentation of this study. This draft has now been released for public review.

Six alternative ways in which the Granby Sanitation District can meet its sewage treatment needs are presented in this draft EIS. These range from taking no action to the construction of the 1.5 MGD plant as proposed in the 1975 plan. One alternative, building a smaller plant (approximately 0.5 MGD size) that could be expanded in the future if needed, has received extensive analysis.

EPA has not made a decision in this draft EIS on which of the alternatives it would fund. However, because the earlier population projections that were the basis of the proposed 1.5 MGD plant have not materialized and because the building of this size plant, at this time, could have significant financial as well as environmental impacts, it would appear that the smaller plant size alternative would be a desirable approach. In addition, use of the present plant, with possible modifications may be adequate for present needs and also provide capacity for some additional population growth.

administering the District's affairs is very aware that the population growth projections that led it to recommend a new 1.5 MGD sewage plant need to be reassessed. The Board, like EPA, is concerned that the local financial burden of a large unused sewage plant, plus its possible environmental effects, must be carefully considered before a final decision on a sewage plant is made.

The decision on this sewage treatment project is an important one that has long-term consequences for the Granby area. Please give this draft EIS your careful review. The Granby Sanitation District, Colorado Department of Health, and EPA need your opinions and concerns before making a decision on this project.

No public hearing has been scheduled on this draft EIS. If, however, you believe that a hearing is necessary, contact my Regional Counsel, James W. Sanderson, as soon as possible setting forth your reasons.

This draft EIS has been sent to the Council on Environmental Quality on March 31,1976. Comments must be received by EPA by May 26, 1976. Please send your comments to:

Office of the Regional Administrator
U.S. Environmental Protection Agency
1860 Lincoln Street - Suite 900
Denver, Colorado, (80203).

John A. Green
Regional Administrator

Enclosures

Granby Sanitation District
Granby, Colorado
EPA Project No. C-080346

(x) Draft ( ) Final Environmental Statement

1. Name of Action: (x) Administrative ( ) Legislative

2. Description of Action: It has been proposed by the Granby Sanitation District to construct new expanded wastewater treatment facilities to replace the existing plant, which serves some 600 permanent and about 1000 visitors in the Granby area. The proposal to build the new facility, a 1.5 MGD secondary level facility with provisions for nitrification of effluent and with discharge to the Fraser River, was prompted by population growth projections mainly associated with a large proposed second home/resort complex adjacent to Granby named Val Moritz. The need for the proposed new treatment plant was developed on the expectation that Val Moritz, and other secondary growth in the Granby area, would result in a population to be served of some 17,000 people by 1990. Over the past several years, the actual growth rate for second homes has fallen far short of early projections made by the developers. Because of the fact that these growth projections have not materialized and because of the realization that a treatment plant with large unused excess capacity could have significant financial as well as environmental impacts, a much smaller treatment facility may be in order. Also, use of the present treatment plant with some level of upgrading, though probably not a long-term solution, remains as a possible alternative at the present time.

3. Environmental Impacts:(of the proposed 1.5 MGD mechanical plant)

(1) Construction activities will cause short-term erosion and downstream sedimentation.

(2) The increase in total stream pollutants will have a long-term selection effect favoring pollutant-tolerant aquatic species.

(3) The implementation of a new wastewater treatment plant will have an effect upon the local tax structure, with probably increases in property tax for Granby residents. This effect will be particularly severe if Val Moritz fails to develop to the extent and at the rates projected.

(4) A new wastewater treatment plant with excess capacity would:

a. lift a certain amount of the growth constraints now existing in the area;

b. lead to possible secondary growth pressures to lower the local per capita tax burden caused by the new plant; and

c. cause secondary impacts due to the induced growth in the general area, including erosion of hillsides and consequent water pollution, loss of critical wildlife habitat, loss of scenic mountain amenities and a drastic (though gradual) change in the style of life in Granby from a quiet rural setting to a more urban one.

4. Alternatives:

The alternatives considered are as follows:

(1) No action.

(2) Construct a new 1.5 MGD facility with discharge to the Fraser River.

(3) Construct a new 1.5 MGD facility with discharge to the Colorado River.

(4) Treatment and land disposal.

(5) Treatment and crop irrigation.

(6) Stage construction of any of the above-mentioned treatment works in three (0.5 MGD) increments .

5. Distribution:

The attached list shows the agencies, groups, and individuals requested to comment on this draft statement.

6. Draft Statement Sent to Council on Environmental Quality:

7. Final Statement Sent to Council on Environmental Quality: NA

# Distribution List

## Draft Environmental Statement
## Granby Sanitation District
## Granby, Colorado 80446

### LOCAL AND REGIONAL AGENCIES

Granby Sanitation District
Town of Granby
Grand County Commissioners
Grand County Planning Commission
Grand County Department of Planning and Development
Grand County Department of Environmental Health
Grand County Assessor's Office
Grand County Department of Social Services
East Grand School District
Granby Finance Director
Granby Water Commissioner
Middle Park Water Conservancy District
Northwest Colorado Council of Governments
Northwest Colorado Areawide Water Quality Planning Organization

### STATE AGENCIES

Colorado Department of Health, Water Quality Control Division
Colorado State University, College of Forestry and Natural Resources
Colorado Department of Health, Air Quality Control Division
Colorado State Department of Highways
Colorado State University, Department of Anthropology
Colorado State Highway Commission
Colorado Division of Game, Fish and Wildlife
Colorado State Division of Planning

### FEDERAL AGENCIES

U.S. Bureau of Reclamation
U.S. Geological Survey
U.S. Forest Service
U.S. Department of Agriculture, Soil Conservation Service
U.S. Bureau of Land Management
U.S. National Park Service
Federal Energy Administration
U.S. Department of Interior
Department of Health, Education, and Welfare
Public Health Service, Department of Health, Education and Welfare
U.S. Department of Housing and Urban Development

FEDERAL AGENCIES (Cont'd.)

Office of Legislation, EPA
Office of Public Affairs, EPA
Office of Water Programs, EPA
Office of Federal Activities, EPA
Council On Environmental Quality

OTHER ORGANIZATIONS AND INDIVIDUALS

Sierra Club, Rocky Mountain Chapter
Del E. Webb Corporation/Val Moritz
Grand County Land Fill and Trash Removal
Leonard Rice Engineers
Nelson, Haley, Paterson, and Quirk, Inc.
Colorado Open Space Council
Northern Colorado Water Conservancy District
Denver Board of WAter Commissioners
Trout Unlimited
Sky High News
The Wilderness Society
The Environmental Defense Fund
National Wildlife Federation
Mr. Paul Geisendorfer, Moraine Park
Tom Bell, Dames and More
Granby Chamber of Commerce

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# SECTION I

# BACKGROUND

## INTRODUCTION

The Granby Sanitation District has applied to the U.S. Environmental Protection Agency for a grant to help construct a new wastewater treatment facility to serve future residential and commercial needs in the designated planning area. The Sanitation District, located in Granby, Colorado is authorized to provide sewerage service, to make appropriate charges for such service and to provide facilities therefor in compliance with the ordinances, regulations and laws of Grand County and the State of Colorado. Accordingly, the Sanitation District retained a consultant to prepare a facilities plan, completed in May 1975. The U.S. Environmental Protection Agency has determined that the proposed Granby Wastewater Treatment Facility is a major project with significant environmental effects. EPA is required by law to prepare an Environmental Impact Statement on such projects. This requirement is pursuant to Section 102(2)(c) of the National Environmental Policy Act of 1969, its amendments and the case law ensuing therefrom.

The U.S. Environmental Protection Agency is preparing this environmental impact statement as documentation of (1) the analysis and deliberation of the environmental and quality-of-life impacts of its possible funding of the proposed wastewater treatment system, (2) the full consideration of the possible courses of action which could be followed to meet and maintain Federal and State water quality standards as related to the Granby Sanitation District, (3) the decision-making process by EPA on its course of action at Granby and (4) the involvement of other agencies and the citizenry in this process. The final EIS will serve as a statement of EPA's course of action on the Granby Sanitation District's proposed action.

The proposed action involves construction of an advanced wastewater treatment facility to replace the existing plant and to accommodate an eventual 5,700 cu m/day [1.5 mgd] flow. The project implementation may take the form of (1) one-stage construction of a 5,700 cu m per day [1.5 mgd] treatment plant with river discharge, (2) a three-stage facilities construction over a 15- to 20-year period, (3) treatment and land disposal in the forest or (4) treatment and reuse for crop irrigation.

**The size of the proposed facility is based upon population projections of up to 17,000 users in 1990. The major portion of this projected growth is to be contributed by a proposed large-scale residential and recreational development (Val Moritz) southeast of Granby. The realization of an almost 11-fold increase in population in the next 15 years is dependent upon many external factors and in fact may not occur. The speculative nature of the proposed development makes population and flow projections highly uncertain.**

This document, an Environmental Impact Statement on the Granby Facilities Plan, describes the existing setting and the proposed actions and their probable impacts. It gives serious consideration to population projections and the secondary effects of growth in the Granby area.

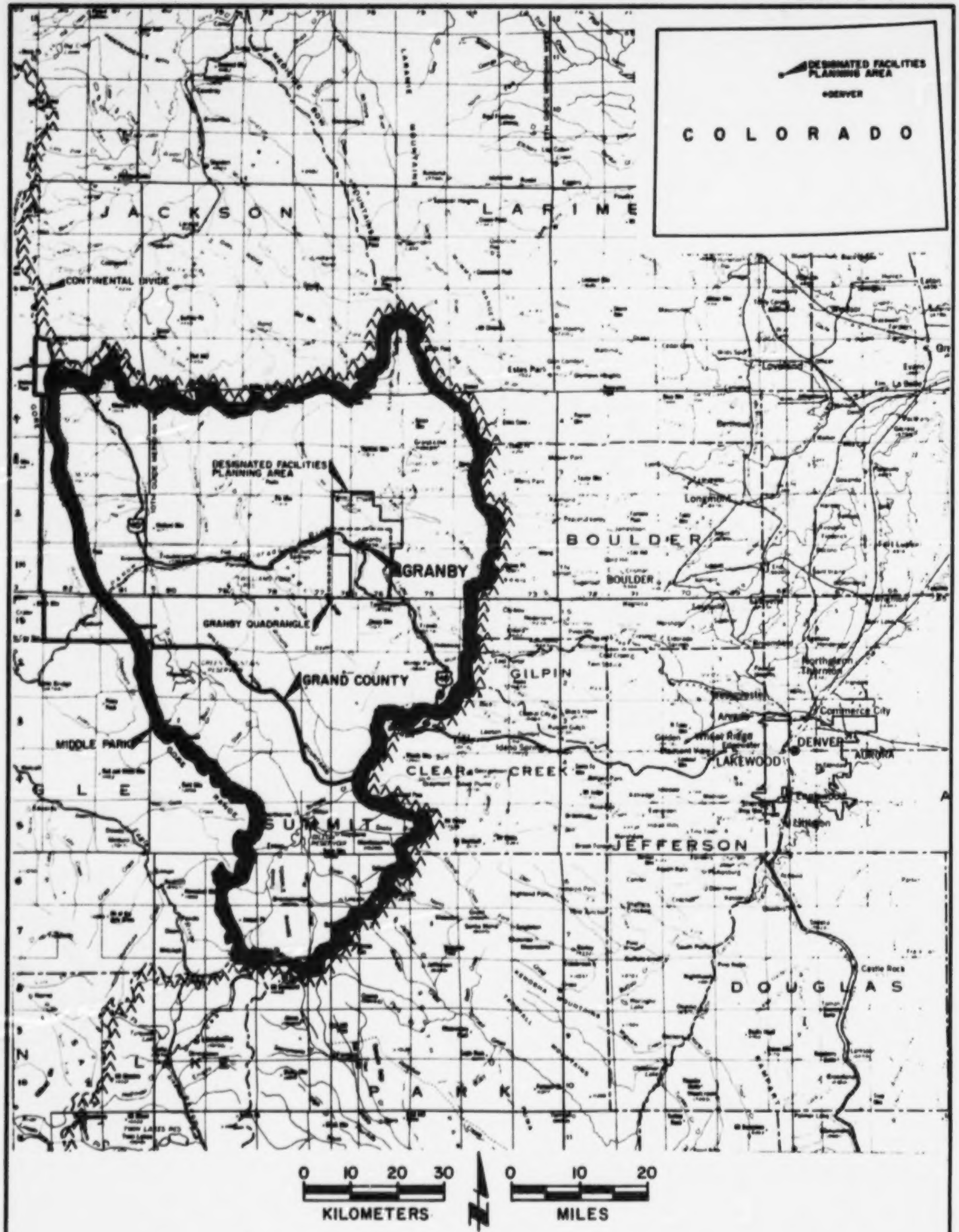
## PROPOSED ACTION

A detailed description of the proposed project is provided in Section IV. Briefly, it is proposed by the Granby Sanitation District to construct new, expanded wastewater treatment facilities to replace the existing plant, which serves some 600 permanent residents and about 1,000 visitors in the Granby area. The new facilities are expected to serve the future waste treatment and disposal needs of the District residents as well as those of the homes to be built at the now-inactive Val Moritz Development Company tracts. Future sewerage needs of the planning area are largely dependent upon the rate of home-buying and building that may occur beyond the spring of 1976, after (or if) Val Moritz resumes sales efforts and starts utilities construction. Even though sewerage expansion needs are dependent on the rate of home building that may occur after the spring of 1976, replacement of the existing sewage treatment plant with a new and possibly different plant may be necessary, whether or not Val Moritz growth actually materializes. Over the past few years, the growth rate for second homes has fallen far short of early projections made by the developers, with the result that sales activities have recently been suspended. However, the size and type of treatment works recommended in the Facilities Plan (Reference 1) were based on those early projections. Insofar as this Draft Environmental Impact Statement is concerned, more than one alternative course of action remains feasible for the Granby Sanitation District to pursue, although the engineering, economic and environmental evaluations of alternatives tend to indicate the desirability of the phased construction of a wastewater treatment plant.

## LOCATION OF PROJECT

The project is located in the eastern part of Grand County, Colorado. A vicinity map of the project area is shown on Figure 1. The planning area recommended in the Colorado River Basin Water Quality Management Plan (Reference 2) includes a large expanse of mountainous

FIGURE I



DESIGNATED FACILITIES PLANNING AREA
DENVER
COLORADO
JACKSON
LARIME
CONTINENTAL DIVIDE
Estes Park
DESIGNATED FACILITIES PLANNING AREA
Longmont
BOULDER
BOULDER
GRANBY
GRANBY QUADRANGLE
GRAND COUNTY
GILPIN
Northglenn
Thornton
Commerce City
Arvada
Wheat Ridge
Golden
DENVER
LAKEWOOD
AURORA
MIDDLE PARK
CLEAR CREEK
SUMMIT
JEFFERSON
Castle Rock
DOUGLAS
LAKE
PARK
0 10 20 30
KILOMETERS
0 10 20
MILES

LOCATION OF THE STUDY AREA

terrain to the north of Granby, which is expected to remain largely unpopulated. This area is also part of the facilities planning area (see Figure 1). The heart of the planning area encompasses the Granby Quadrangle (USGS standard 7.5 minute topographic map), shown on Figure 2, and will be the portion most intensively affected by the planned developments, the new treatment facilities and their potential interrelationships. Therefore, most of the comments in this document will concentrate on this particular part of the planning area while assuming that the northern portion will more probably remain undeveloped through 1995.

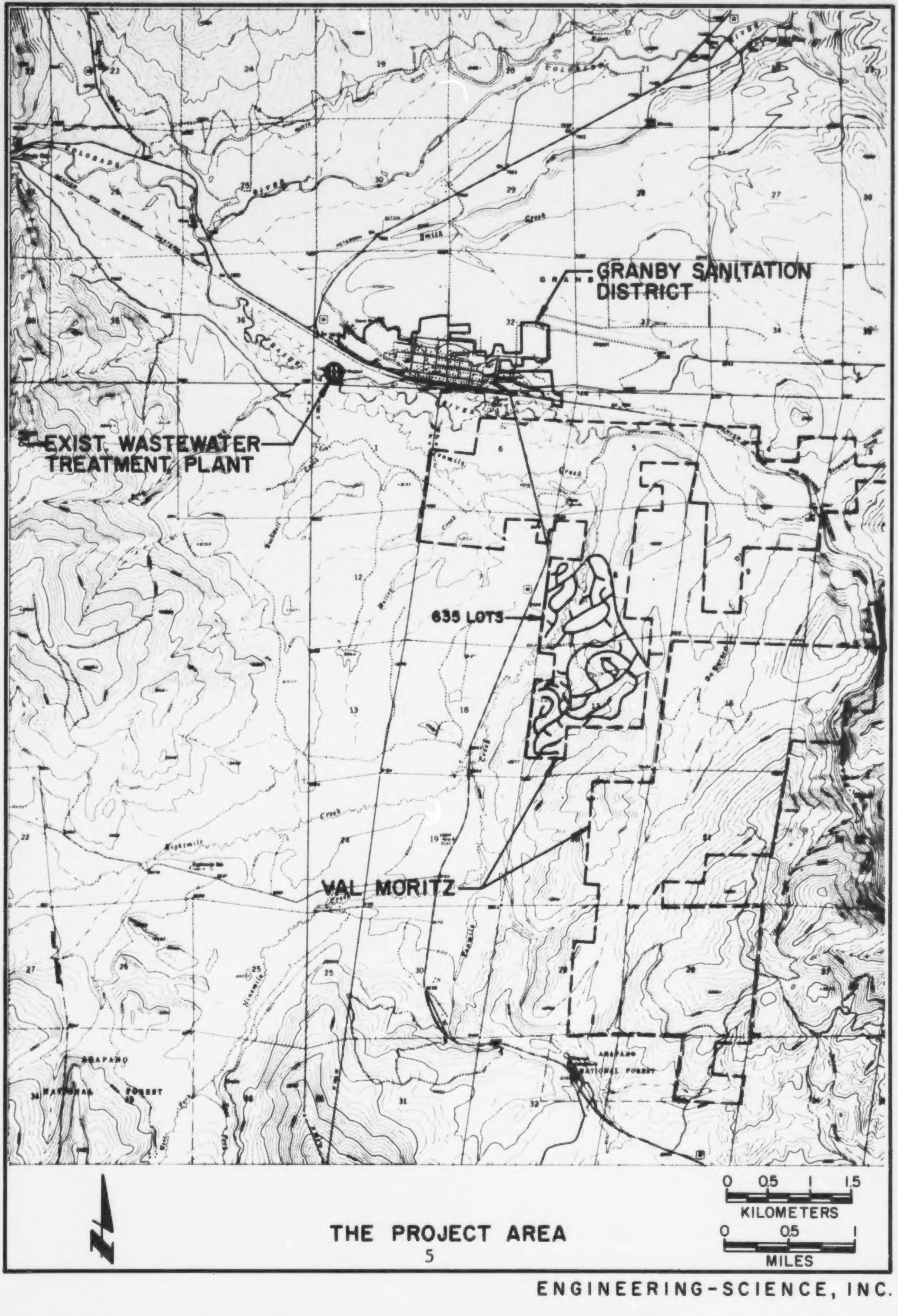
The proposed development master plan for Val Moritz, in the southern part of the planning area, is summarized graphically on Figure 3, showing the proposed high-intensity residential tracts, tourist facilities, recreational areas and support services. The portion of the development area slated for early implementation and divided into individual plots is identified as Innsbruck Val Moritz and involves 635 single-family units with about 0.13-hectare [1/3-acre] individual lots. This subdivision has already been approved by the Grand County Planning Commission. These and other planned second-home developments, shown on Figure 3, were initially speculated for subdivision and construction over the next 15 years, with an ultimate seasonal peak population of 17,000 persons. However, the general national economic conditions of the past few years and the necessary recovery period will probably culminate in a generally less luxurious way of life, making second-home development questionable. Thus, a more realistic projection of future service area population would probably be an order of magnitude below the initial speculations. Lot sales at Val Moritz have been suspended, pending provision of essential services and, presumably, improved economic conditions.

At the present time (February 1976) there is no formal agreement between Val Moritz and the Granby Sanitation District *vis-a-vis* provision of sewerage service to Val Moritz and sharing of the burden involved.

The project area is located primarily in the Fraser River Hydrologic sub-basin, which is one of the uppermost watersheds in the Colorado River Basin. Granby is on the northern shore of the Fraser River, downstream from several winter recreational and other seasonal residential communities: Winter Park, Hideaway Park, Fraser and Tabernash.

Though the present Granby sewage treatment plant discharges to the Fraser River, the town is located near the confluence of the Fraser River with the Colorado River. Upstream from Granby on the Colorado are the water storage facilities of the U.S. Bureau of Reclamation's Colorado-Big Thompson Project, the highly developed resort and second-home area around the Colorado-Big Thompson's three lakes, and Rocky Mountain National Park.

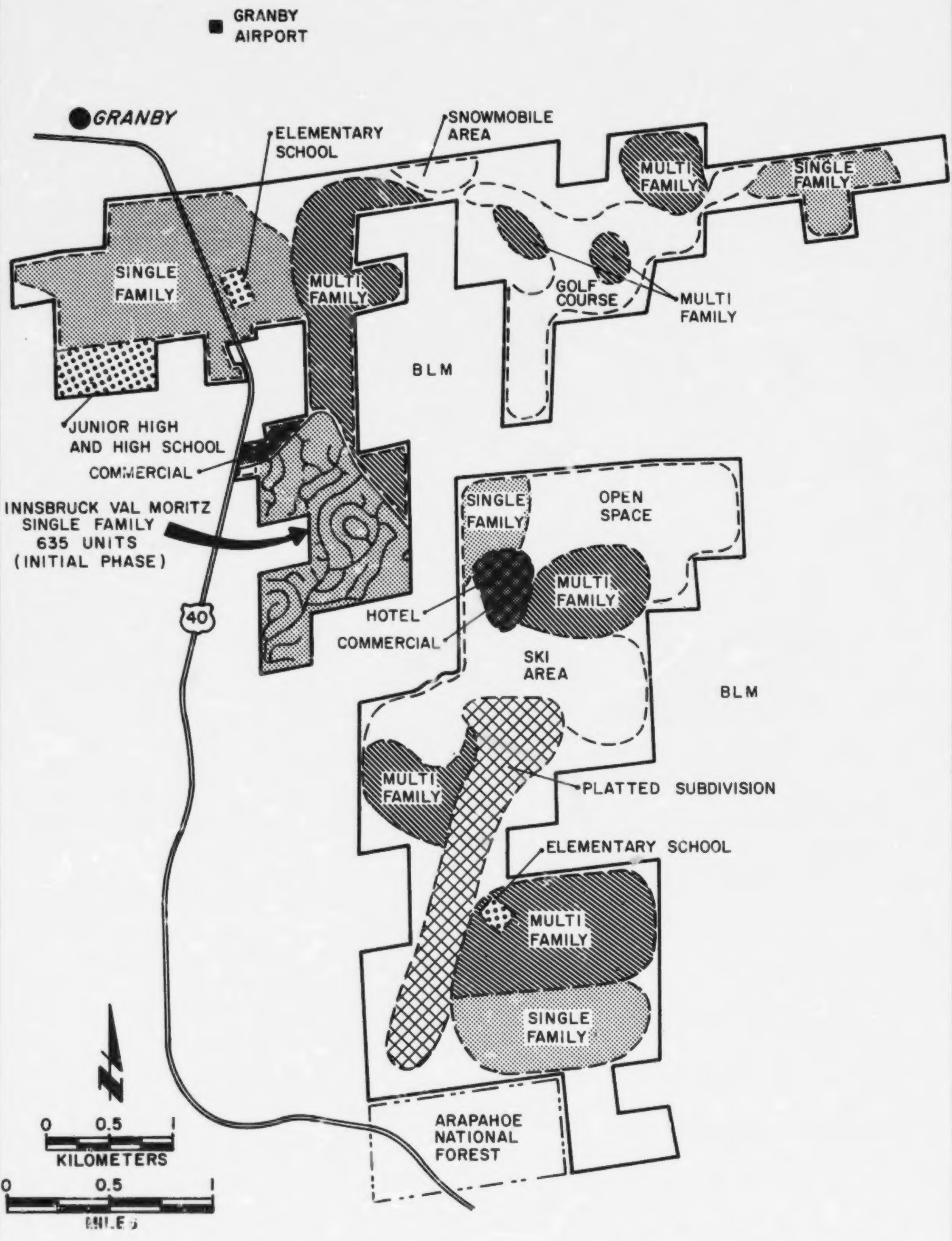
FIGURE 2


GRANBY SANITATION DISTRICT
EXIST. WASTEWATER TREATMENT PLANT
635 LOTS
VAL MORITZ
0 0.5 1 1.5
KILOMETERS
0 0.5 1
MILES
COLORADO RIVER
ARAPAHO NATIONAL FOREST

THE PROJECT AREA

ENGINEERING-SCIENCE, INC.

FIGURE 3


GRANBY AIRPORT
GRANBY
ELEMENTARY SCHOOL
SNOWMOBILE AREA
MULTI FAMILY
SINGLE FAMILY
SINGLE FAMILY
MULTI FAMILY
GOLF COURSE
MULTI FAMILY
BLM
JUNIOR HIGH AND HIGH SCHOOL
COMMERCIAL
INNSBRUCK VAL MORITZ SINGLE FAMILY 635 UNITS (INITIAL PHASE)
SINGLE FAMILY
OPEN SPACE
MULTI FAMILY
HOTEL
COMMERCIAL
40
SKI AREA
BLM
MULTI FAMILY
PLATTED SUBDIVISION
ELEMENTARY SCHOOL
MULTI FAMILY
SINGLE FAMILY
ARAPAHOE NATIONAL FOREST
0
0.5
1
KILOMETERS
0
0.5
1
MILES

VAL MORITZ PROPOSED DEVELOPMENTS MASTER PLAN

## WATER QUALITY AND QUANTITY PROBLEMS

Though water rights have long received attention in the Granby area and in the downstream reaches of the Colorado River in quantitative terms, water quality problems are a more recent consideration. It should be pointed out that in western United States waters such as the Fraser and Colorado Rivers, the quantity of flow and the quality of the water flow are inextricably interwoven. Stream flow depletions, point source stream discharges, erosion and sedimentation, dilution factors, etc. are most important quality and quantity factors that communities, irrigators and industries which depend on the Colorado River for their existence and well-being are concerned with in terms of upstream water uses such as those found in the Granby area.

Little information on water quality in the Fraser River is available. A brief study in the summer of 1973 indicated that river waters were of high quality; dissolved oxygen content was at or near saturation and nutrient and bacteria concentrations were low. The river is, however, the recipient of a number of wastewater discharges which probably have an adverse impact on water quality and aquatic habitats, at least locally, although the deleterious effects have gone unrecorded to date. Recognizing these problems, the Water Quality Control Commission of the Colorado Department of Health has designated the Fraser River as a "water quality limited" stream segment. This is a stream segment in which water quality does not now meet water quality standards and is not expected to meet such standards even after application of secondary treatment to all municipal discharges and best practicable treatment to all industrial point discharges. In accordance with EPA requirements for water quality limited segments, a waste load allocation (or allocation of available assimilative capacity between dischargers) was performed as a part of the basin planning activity. This allocation led to a recommendation of strict ammonia and residual chlorine effluent limitations for the Granby discharge.

Water supplies in the planning area are adequate in quantity for the foreseeable future. Existing agricultural activities are not limited by availability of water.

Water quality and quantity conditions in the planning area are discussed more fully in Section III.

## WATER QUALITY OBJECTIVES

Water quality objectives for the waters of the State of Colorado are primarily defined by the Colorado Department of Health (Reference 3). State waters include both surface and groundwater supplies. Basic standards adopted and applicable to all State waters are succinctly stated on pages 5 and 6 of the Water Quality Standards and Stream Classification by the Colorado Department of Health:

(1) All state waters shall be:

a. free from substances attributable to municipal, industrial, or other discharges or agricultural practices, which will settle to form objectionable sludge deposits;

b. free from floating debris, scum, and other floating materials attributable to municipal, industrial, or other discharges or agricultural practices, which are present in amounts sufficient to be unsightly or deleterious;

c. free from materials attributable to municipal, industrial, or other discharges or agricultural practices, which produce color, odor, or other conditions in such a degree as to create a nuisance or impart any undesirable taste to fish flesh or in any way make fish inedible;

d. free from substances attributable to municipal, industrial, or other discharges or agricultural practices in concentrations or combinations which are toxic or harmful to human, animal, plant, or aquatic life;

e. free from substances and conditions or combinations thereof attributable to municipal, industrial, or other discharges or agricultural practices in concentrations which produce undesirable aquatic life;

f. free from residues attributable to wastewater or visible film oils or globules of grease, which are present in concentrations which cause a film, other discoloration of the surface, or which cause an emulsion to be deposited beneath the surface of the water or upon adjoining shorelines or which prevent classified uses of such waters.

(2) The radioactivity of surface waters shall be maintained at the lowest practical level and shall in no case, except when due to natural causes, exceed the latest Federal Drinking Water Standard as established by the United States Public Health Service, the Environmental Protection Agency or their successor.

(3) The Commission presently has not adopted a standard regarding salinity, but has reserved this section for such criteria. Since Colorado has been collecting and analyzing stream samples for a relatively short period of time, it is felt that insufficient data is available to set numerical standards at this time. In addition, technological know-how has not advanced to the point where all sources of salinity (irrigation return flows, for example) can be resolved. Therefore, Colorado proposes, where possible, to maintain salinity concentrations at or below present levels while gathering additional data so that meaningful numerical salinity standards can be established at some future date. In the

> *meantime, Colorado will continue to take action against known discharges contributing to the salinity problem where present technology allows for such control; continue with demonstration projects, such as the Grand Valley Project; and, through whatever means available, strive to educate the irrigator in proper water management and irrigation practices.*
>
> *With regard to the Colorado River system and its tributaries, the State of Colorado will cooperate with other Colorado River Basin states and the Federal Government to support and implement the conclusions and recommendations adopted April 27, 1972, by the reconvened 7th Session of the Conference in the Matter of Pollution of the Interstate Waters of the Colorado River and its tributaries.*

On the basis of these objectives, the State has established water quality standards and discharge limitations. These are discussed in Section III under Water. The State has further provided an antidegradation statement intended to protect those waters whose quality presently exceeds the standards promulgated to date. The antidegradation objective is applicable to the conditions prevailing in the Granby area, with many constituents in the streams at levels far below the standard limits.

## COSTS AND FINANCING

In order to construct facilities considered in any one of the alternatives (excluding the no-action alternative) discussed in Section IV for the full projected flow of 5,700 cu m/day [1.5 mgd], a capital expenditure ranging from $2.6 to $4.1 million would be required, depending on the alternative ultimately selected. If the project were built in three equal stages, capital expenditures would amount to $4.8 million. Any of the four treatment and disposal alternative schemes can be staged, with a similar increase in overall capital expenditures. However, for the purposes of brevity and simplicity, the staging of the facilities planning consultant's recommended scheme is analyzed and presented as an example.

If approved, the U.S. Environmental Protection Agency will pay 75 percent of the grant-eligible portion of the capital cost and the local entities will bear the remaining 25 percent, as provided by the Federal Water Pollution Control Act as amended in 1972.

The local share (25 percent) of the capital cost will have to be borne proportionately by the users; i.e., the Granby Sanitation District and the Val Moritz Development Company. The fair proportion of funds supplied by each entity is determined by the EPA as the ratio of design wastewater flow from that entity to the total flow into the facilities thus funded. According to the Facilities Plan (Reference 1), this amounts to 30 percent funding by the Granby Sanitation District and 70 percent by the Val Moritz Development Company. The Facilities Plan recommends financing of the Granby share through "tap and service" fees as well as charges for "pretreatment and septage dumping." It further recommends that the District retain a financial consultant to arrange the necessary details. As for the 70 percent funding by Val Moritz, it is assumed that bonding or other arrangements can be made to secure the required advance and annual payments.

## HISTORY OF GRANT APPLICATIONS FOR WASTEWATER TREATMENT FACILITIES

The Colorado River Basin Water Quality Management Plan (Reference 2), published in January 1975 and adopted in final form in August 1975, recommended a new wastewater treatment plant downstream of the existing facility. It specified nitrification to reduce ammonia concentrations in the effluent, disinfection using ozone to prevent toxicity to aquatic biota and provision of enclosures for certain treatment units to prevent cold-weather disruption of the physical and biological processes. On the basis of these recommendations and effluent characteristics of existing Granby discharges, the Colorado State Department of Health initially placed the Granby Sanitation District high on the Fiscal Year 1975 priority list for wastewater treatment works (Step 1 and Step 2) grants. Subsequently, the priority listing for Granby dropped and was eliminated, due in part to improved plant performance.

The Granby Sanitation District applied to the U.S. Environmental Protection Agency on 15 October 1974 for a Step 1 grant for the preparation of a Facilities Plan for possible treatment works improvements. That application was approved on 6 December 1974, and the grant was accepted by the Granby Sanitation District on 18 December 1974. The resulting Facilities Plan was published in February 1975. On 9 June 1975 the Regional Administrator of the U.S. Environmental Protection Agency sent a "Notice of Intent to Prepare an Environmental Impact Statement" for "Approval of the Granby Water and Sanitation District's Water Quality Management Planning Study" to government agencies, public groups and citizens. On 30 June 1975 EPA authorized Engineering-Science, Inc. to prepare an Environmental Impact Statement on the proposed action.

The objective of an Environmental Impact Statement is to analyze and fully publicize the environmental impacts, including physical, biological, social, aesthetic, economic and quality-of-life impacts, associated with the proposed project. Where these impacts are unacceptable, changes to or deletions of parts of the system are proposed. In the extreme cases of highly adverse impacts, a no-action course may be proposed.

# SECTION II

# SUMMARY AND CONCLUSIONS

## INTRODUCTION

Intense land development speculation during the last five years led to the conclusion that the town of Granby and its surrounding areas might be at the threshold of a substantial population increase. Projections made in the economic milieu of the early 1970's predicted an 11-fold population increase in the Granby area during the next 15 years. Due to present and future national economic conditions and the speculative nature of land development in general, there is some uncertainty about the nature and extent of future growth. On the basis of actual growth rates in the recent past, a wastewater treatment facility large enough to accommodate the populations projected in the 1970's could be a poor investment for the residents of Granby. Thus, such an undertaking must be carefully evaluated before the commitment of large capital expenditures.

## ALTERNATIVES

Six feasible alternatives, comprising a wide range of choices for the people of Granby, were evaluated for environmental, social and economic impacts. These alternatives are:

1. No action. The existing secondary level of wastewater treatment would be maintained and discharge of effluent continued to the Fraser River. No attempts would be made to expand service for future population growth. This alternative currently meets discharge standards, with the exception of the total residual chlorine requirement. The plant, with minor modifications, will be adequate to service the needs of the most conservatively estimated future populations to 1995 but would not meet the stringent ammonia mass-emission requirements recommended in the basin plan and likely to be included in future discharge permit conditions for Granby.

2. Construct new facility with disposal to the Fraser River. This alternative would provide a new 5,700 cu m per day [1.5 mgd] biological, secondary-level treatment facility with provisions for nitrification of the effluent. The facility would be near the site of the existing plant, and its effluent would be discharged to the Fraser River. Excepting the no-action alternative, this alternative has the

lowest capital construction cost and next to the lowest annual operation and maintenance cost, assuming that the maximum projected growth materializes.

3. Construct new facility with disposal to the Colorado River. Although treatment levels would be essentially the same as those in the previous alternative, the higher dilution capacity of the Colorado River would make the effluent quality restrictions necessary to meet water quality standards less severe. Longer wastewater treansport distances, to the treatment site along Highway 125 north of Highway 40 and to the Colorado River, make this alternative more costly than the second alternative. For economic comparison with the above alternative, this facility was analyzed assuming maximum population growth conditions.

4. Treatment and land disposal. Raw wastewaters from Granby would be pumped to a lagoon treatment system in the Arapaho National Forest and sprayed onto the land after treatment. Land disposal requirements are low, and the less efficient but also less costly lagoon treatment process would be adequate. However, the short summer season necessitates large ponds for storing the effluent during the winter, a costly item. Spray irrigation systems also have high capital cost. Groundwater pollution and nitrogen accumulation are potential problems but can be mitigated.

5. Treatment and crop irrigation. Raw wastewaters would be treated in lagoons on the Granby Mesa. During the summer growing season, chlorinated secondary-level effluent would be sprayed onto hay fields. Again, winter storage costs would be high, but savings could be realized in the low operation and maintenance costs.

6. Staged construction of any of the above-mentioned treatment works in three 1,900 cu m per day [0.5 mgd] capacity increments. To provide an example, the facilities involved in Alternative 2 were analized for staged construction. It was found that staged construction of facilities is only slightly more costly than one-time construction and that compared to unstaged construction it would afford tremendous savings to the residents of Granby in case Val Moritz failed to develop: if the larger (5,700 cu m per day [1.5 mgd]) plant were to be constructed and Val Moritz did not develop, a large tax burden would be placed upon the residents of Granby for the largely wasted capacity of an under-used plant. Alternatives 2 through 5 are all amenable in differing degrees to staged construction.

## THE ENVIRONMENT

Granby and the Granby Sanitation District are located in a high mountain valley known as Middle Park and are surrounded by various ranges of the north-central Colorado segment of the Rocky Mountains.

The area is characterized by a short growing season, severe climatic conditions, high mountains, irrigated river valleys and extensive forest lands. The natural beauty of the area, its proximity to Rocky Mountain National Park and to other extensive public lands managed by the U.S. Forest Service, its accessibility to several major ski areas and its location on a major Federal highway result in a large and growing use and visitation of the area by vacationers and recreationists. In fact, it is these very amenity and locational factors which have resulted in substantial growth and development pressure on the planning area. Ironically, this very growth and development, unless adequately controlled, could severely damage the very values which attracted it in the first place.

Of particular importance in the natural environment of Granby are the wildlife habitats in the southeastern part of the planning area. Critical winter range areas for deer and elk have been identified by Colorado wildlife officials at locations coinciding with plans for development of relatively high-density residential areas.

An important and unique feature of the planning area is its situation near the headwaters of the Colorado River System. Also of importance to the Granby area and to those who use it are the quality fisheries of the Fraser and Colorado Rivers. Protection of these fishery resources is a priority element of environmental planning for the area. The implications of these important features *vis-a-vis* the wastewater management practices in the area and their potential impacts upon downstream users of the river are considered here.

## ENVIRONMENTAL IMPACTS

The major beneficial and adverse environmental impacts of all alternatives considered are summarized below:

### Alternative 1

1. The existing wastewater treatment plant will continue to contribute ammonia-nitrogen and residual chlorine to the Fraser River. These pollutants are critical to a water quality limited stream and could lead to significant adverse effects upon aquatic life.

2. Adoption of a no-action course could lead to the formation of a separate sanitation district for Val Moritz if Val Moritz does develop. Such a district would probably use either package plants or septic tanks. In case of reliance on septic tanks, the minimum one-hectare [2-acre] lot size required by Grand County would necessarily lead to a redesign of Val Moritz's subdivision plans. Septic tanks generally contribute to groundwater pollution, and package plants tend to be unreliable in nearly all situations.

3. Unavailability of excess sewerage capacity would discourage residential and commercial developments from encroaching on this high mountain valley and thereby help it to retain its natural aesthetic environment and critical wildlife habitats.

Alternatives 2 and 3

1. Construction activities will cause short-term erosion and downstream sedimentation.

2. The increase in total stream pollutants will have a long-term selection effect favoring pollutant-tolerant aquatic species.

3. The implementation of a new wastewater treatment plant will have an effect upon the local tax structure, with probable increases in property tax for Granby residents. This effect will be particularly severe in Alternatives 2 and 3 if Val Moritz fails to develop to the extent and at the rates projected.

4. A new wastewater treatment plant with excess capacity (whether 1,900 cu m per day [0.5 mgd] or 5,700 cu m per day [1.5 mgd]) would:

a. lift a certain amount of the growth constraints now existing in the area;

b. lead to possible secondary growth pressures to lower the local per capita tax burden caused by the new plant; and

c. cause secondary impacts due to the induced growth in the general area, including erosion of hillsides and consequent water pollution, loss of critical wildlife habitat, loss of scenic mountain amenities and a drastic (though gradual) change in the style of life in Granby from a quiet rural setting to a more urban one.

Alternative 4

1. Construction activities will cause short-term erosion and downstream sedimentation.

2. Forest irrigation will lead to a shift in the existing lodgepole pine ecosystem.

3. Long-term irrigation may lead to the accumulation of nitrates in groundwater and materials which may decrease soil productivity.

4. Construction of large stabilization ponds permanently removes that area from the natural environment and alters land forms.

5. Cessation of pollutant discharge into the Fraser River will

improve stream water quality for all downstream communities along the Colorado River System. It will also lower the flows in the river.

6. Groundwater pollution may occur if proper design and operational techniques are not rigorously followed.

7. The visual and aesthetic environment may be adversely affected.

8. The implementation of new wastewater treatment works will have an effect on the local tax structure, with probable increases in property tax for Granby residents, unless the project is constructed in stages, as needed.

9. Failure to return waters to the stream has legal implications which may be significant to senior appropriators of downstream waters.

Alternative 5

1. Construction activities will cause short-term erosion and downstream sedimentation.

2. Construction of large aerated ponds permanently removes that area from the natural environment.

3. Although the habitat type will be altered, agricultural techniques could be utilized to mitigate this impact to the benefit of wildlife.

4. Irrigation enhances the productivity and feasibility of agriculture on the Granby Mesa area.

5. Groundwater pollution may occur if proper site selection and application techniques are not followed.

6. The visual and aesthetic environment may be adversely affected.

7. The implementation of new wastewater treatment works will have an effect on the local tax structure, with probable increases in property tax for Granby residents, unless the project is constructed in stages, as needed.

8. Cessation of pollutant discharge into the Fraser River will improve stream water quality for all downstream communities along the Colorado River System. Simultaneously, it would reduce stream flows and potentially affect water rights of senior appropriators.

Alternative 6

1. Construction activities will cause short-term eorsion and down-

stream sedimentation. Staged construction would partially spread this damage over a longer period of time and permit regrowth of vegetation between stages.

2. The increase in total stream pollutants will have a long-term selection effect favoring pollutant-tolerant aquatic species.

3. Even a staged project with initial treatment capacity of 1,900 cu m per day [0.5 mgd] will have a growth-inducing impact through eliminating the constraint now provided by inadequate excess sewerage service. Such induced growth would cause secondary impacts in the planning area. These impacts include (a) erosion of soils on construction sites and consequent water pollution and loss of critical wildlife habitat; (b) loss of scenic mountain amenities and (c) a drastic (though gradual) change in life style from a quiet rural setting to a more urban one. These secondary impacts can be expected under the staged (or unstaged) construction of any alternative (2, 3, 4 or 5).

# SECTION III

# ENVIRONMENTAL SETTING

## PHYSICAL ENVIRONMENT

The planning area is situated near the crest of the Southern Rocky Mountains, cradled by the Continental Divide. The mountain ranges surrounding the planning area are the Rabbit Ears Range to the north, the Front Range on the east, the Williams Fork Mountains on the southwest and the Gore Range on the west. The north-central portion of the Southern Rocky Mountain Province contains the Fraser hydrologic subbasin, one of the headwaters of the Colorado River, which in turn contains the planning area.

In terms of environmental quality, this is the area where the Colorado River has retained many of its mountain-origin, pristine qualities, where the air is clean and where aesthetic qualities related to undeveloped natural landscapes are still prevalent. It is the protection of these qualities which presents a very real need and challenge to government and for concerned citizenry. The U.S. Environmental Protection Agency, in cooperation with other agencies involved, intends to maintain this high quality environment by the intelligent and judicious application of its authorities.

### Climate

Climate has a direct bearing on the impact a wastewater treatment facility will have upon receiving waters and other environmental parameters. Low temperature can limit reliability of biological treatment systems; winds carry odors; frost-free season and evapotranspiration rates affect land application of effluents; and rainfall determines many other constraints.

The climate of the planning area can be described generally as continental, influenced by elevation and topography. Much of the moisture from the prevailing westerlies is removed by the mountains to the west. Mountain ranges to the north and east provide some protection from cold north winds. The area generally has cool summers, extremely cold winters, low humidity, little precipitation and abundant sunshine. Wide daily temperature ranges are common, and variations in elevation cause temeprature differences within the area (Reference 1).

The nearest weather station is located just outside the planning area to the northwest, at a Bureau of Reclamation pumping plant on Lake Granby, 9.7 km [6.0 miles] south-southwest of Grand Lake. This station is close enough to Granby (8 km [5 miles]), with no significant topographical obstructions between the two locations, so that its weather data can be assumed to be applicable to the whole planning area. Isoline data from generalized National Weather Service maps (Reference 4) support this assumption. Temperature, precipitation, snowfall and evaporation data from the Grand Lake (6 SSW) station are shown in Table 1 and on Figures 4 and 5. Wind data collected by Rocky Mountain Airways at the Granby Airport are presented in Table 2. Generally, Granby experiences high winds from the west, which are funneled through the appropriately named Windy Gap. Weather data from two other nearby stations, Hot Sulphur Springs and Fraser, are presented in Table 3. Since the rugged topography separating these three stations causes large climatic variations within short distances, the data from the latter two stations are intended to provide a regional perspective rather than a representative situation.

Table 2. WIND DATA, GRANBY AIRPORT

| Wind | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Approx. 8:00 a m | | | | | | | | | | | | |
| knots | 4.0 | 2.2 | 3.5 | 3.1 | 2.7 | 2.0 | 0.2 | 0.3 | 0.2 | 0.9 | 2.4 | 3.6 |
| [mps] | 2.1 | 1.1 | 1.8 | 1.6 | 1.4 | 1.0 | 0.1 | 0.2 | 0.1 | 0.5 | 1.2 | 1.9 |
| Approx. 1:00 p m | | | | | | | | | | | | |
| knots | 9.9 | 6.8 | 11.2 | 13.2 | 12.2 | 14.2 | 8.6 | 11.5 | 12.6 | 10.8 | 9.9 | 8.0 |
| [mps] | 5.1 | 3.5 | 5.8 | 6.8 | 6.3 | 7.3 | 4.5 | 6.0 | 6.5 | 5.6 | 5.1 | 4.1 |

**Source: Rocky Mountain Airways, Granby Airport, Granby, Colorado.**

The average temperature usually remains below freezing from November through April, and the ground is frozen during this period. Freeze data presented in Tables 4 and 5 show that the average number of days between the last spring freeze and the first fall freeze is 41 days, with a range from one day to 83 days. The growing season for crops is defined according to these freeze data and is approximately two months or less.

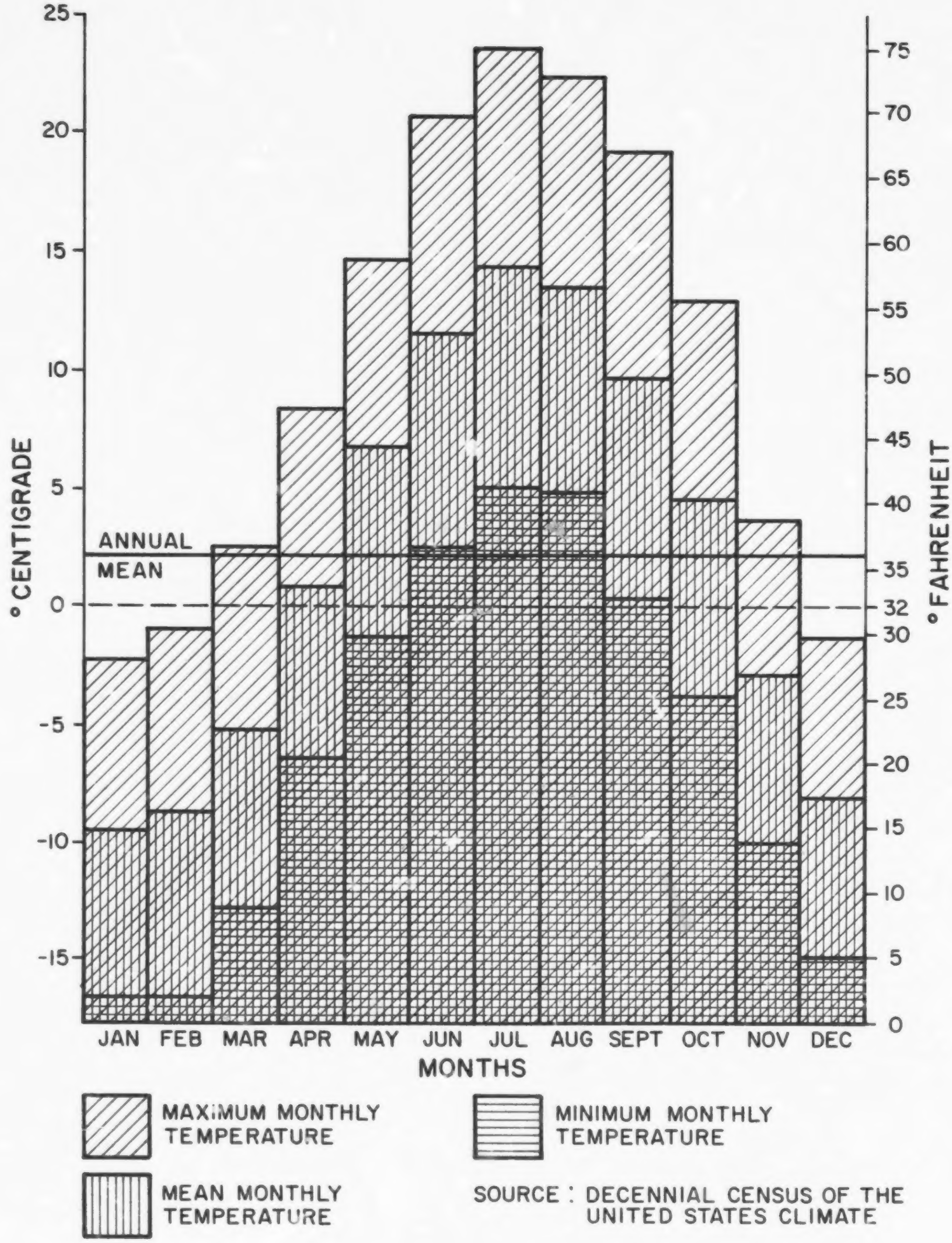
The Granby area generally receives approximately 3 m [10 feet] of snow annually, with most snow falling between October and April. The area is relatively arid, and evaporative stress is high during the summer months, indicating that plants could utilize more water if it were available. The low relative humidity of the area, rather than the sum-

Table 1. TEMPERATURE, PRECIPITATION, SNOW AND EVAPORATION, GRAND LAKE (6 SSW)

| Parameter | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Temperature** | | | | | | | | | | | | | |
| Mean daily | | | | | | | | | | | | | |
| °C | 9.5 | -8.8 | -5.3 | 0.8 | 6.8 | 11.7 | 14.6 | 13.8 | 10.1 | 4.7 | -2.9 | -8.1 | 2.3 |
| [°F] | 14.9 | 16.1 | 22.5 | 33.5 | 44.2 | 53.0 | 58.2 | 56.9 | 50.1 | 40.5 | 26.7 | 17.4 | 36.2 |
| Average max. | | | | | | | | | | | | | |
| °C | -2.3 | -1.0 | 2.3 | 8.2 | 14.8 | 20.9 | 23.8 | 22.5 | 19.6 | 13.1 | 4.0 | -1.3 | 10.4 |
| [°F] | 27.9 | 30.1 | 36.2 | 46.7 | 58.6 | 69.6 | 74.9 | 72.5 | 67.2 | 55.6 | 39.2 | 29.6 | 50.7 |
| Average min. | | | | | | | | | | | | | |
| °C | -16.7 | -16.7 | -12.9 | -6.6 | -1.2 | 2.4 | 5.3 | 5.2 | 0.5 | -3.7 | -9.9 | -14.8 | -5.8 |
| [°F] | 1.9 | 1.9 | 8.8 | 20.2 | 29.8 | 36.3 | 41.5 | 41.3 | 32.9 | 25.3 | 14.2 | 5.3 | 21.6 |
| **Precipitation** | | | | | | | | | | | | | |
| mm | 29.0 | 22.1 | 30.7 | 27.7 | 39.6 | 30.5 | 40.4 | 47.8 | 26.2 | 20.1 | 18.8 | 33.5 | 366.3 |
| [in.] | 1.14 | .87 | 1.21 | 1.09 | 1.56 | 1.20 | 1.59 | 1.88 | 1.03 | .79 | .74 | 1.32 | 14.42 |
| **Snow** | | | | | | | | | | | | | |
| cm | 47.8 | 39.1 | 37.6 | 38.1 | 10.9 | 3.0 | 0 | 0 | 0.3 | 12.7 | 24.6 | 47.5 | 261.6 |
| [in.] | 18.8 | 15.4 | 14.8 | 15.0 | 4.3 | 1.2 | 0 | 0 | 0.1 | 5.0 | 9.7 | 18.7 | 103.0 |
| **Evaporation** | | | | | | | | | | | | | |
| mm | na[a] | na | na | na | 121.4 | 213.4 | 210.3 | 176.3 | 147.1 | 83.8 | na | na | 952.0 |
| [in.] | na | na | na | na | 4.78 | 8.40 | 8.28 | 6.94 | 5.79 | 3.29 | na | na | 37.48 |

[a] Evaporation values are not available for these months in the references cited.

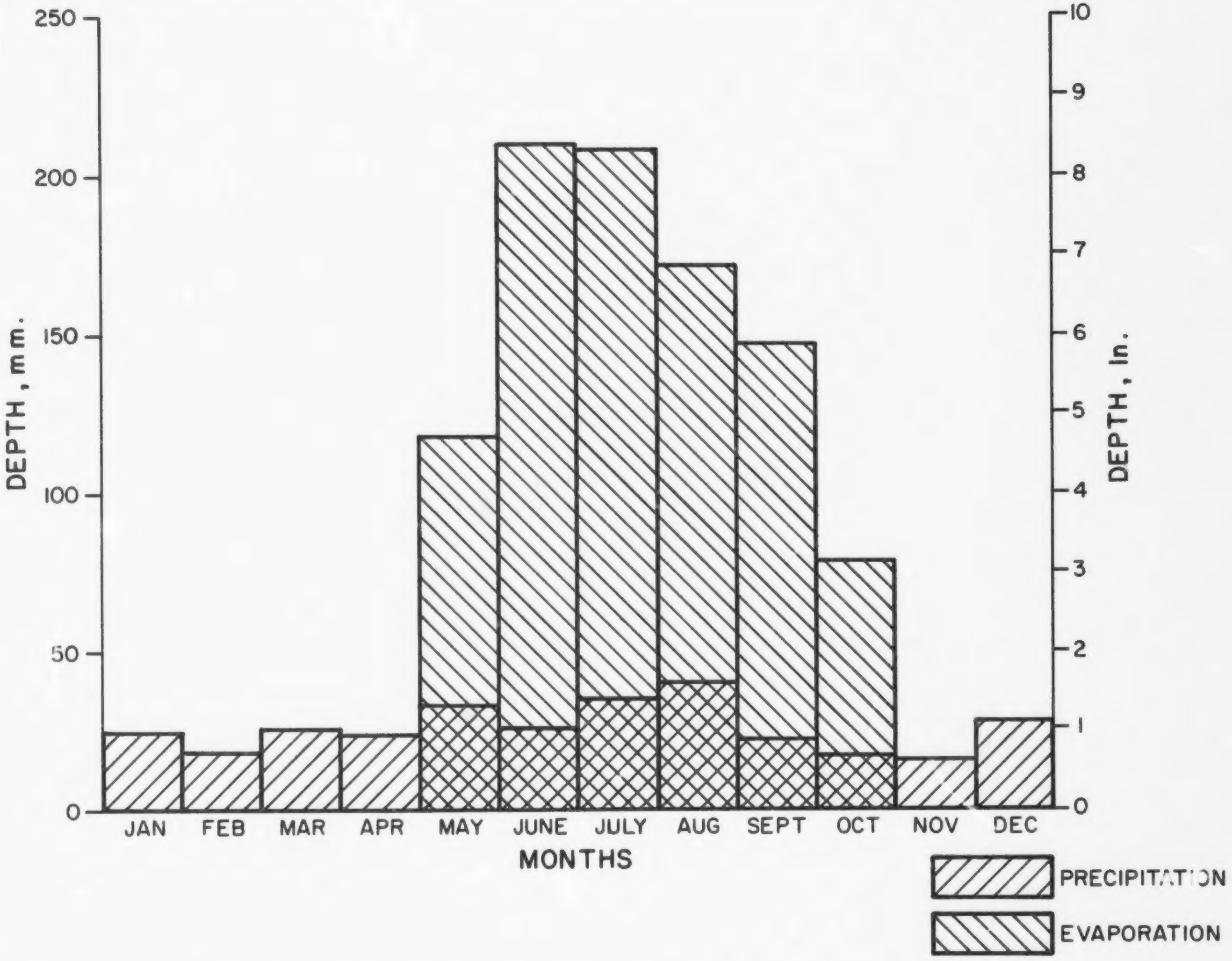
Source: Decennial Census of United States Climate; Climatological Data, Colorado (References 5 and 6).



SOURCE : DECENNIAL CENSUS OF THE UNITED STATES CLIMATE

MAXIMUM, MINIMUM AND MEAN MONTHLY TEMPERATURES
GRAND LAKE (6SSW) 1951-1960

FIGURE 5



MONTHLY PRECIPITATION AND EVAPORATION (1961-1970)
FOR GRAND LAKE (6SSW)

## Table 3. TEMPERATURE, PRECIPITATION AND SNOW, FRASER AND HOT SULPHUR SPRINGS

| Parameter | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Temperature |  |  |  |  |  |  |  |  |  |  |  |  |  |
| (mean daily) |  |  |  |  |  |  |  |  |  |  |  |  |  |
| °C | -10.5 | -9.6 | -6.6 | -0.7 | 5.4 | 9.9 | 12.4 | 11.3 | 7.0 | 1.8 | -5.8 | -10.3 | 0.4 |
| [°F] | 13.1 | 14.7 | 20.2 | 30.7 | 41.8 | 49.8 | 54.4 | 52.4 | 44.6 | 35.3 | 21.6 | 13.5 | 32.7 |
| Precipitation |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Fraser |  |  |  |  |  |  |  |  |  |  |  |  |  |
| mm | 47.8 | 37.8 | 49.3 | 46.7 | 49.5 | 35.3 | 38.4 | 40.6 | 32.8 | 26.7 | 31.0 | 41.9 | 478.0 |
| [in.] | 1.88 | 1.49 | 1.94 | 1.84 | 1.95 | 1.39 | 1.51 | 1.60 | 1.29 | 1.05 | 1.22 | 1.65 | 18.82 |
| Hot Sulphur S. |  |  |  |  |  |  |  |  |  |  |  |  |  |
| mm | 22.9 | 19.6 | 25.4 | 27.4 | 31.8 | 25.7 | 37.1 | 30.2 | 30.5 | 22.1 | 2.01 | 16.3 | 308.9 |
| [in.] | .90 | .77 | 1.00 | 1.08 | 1.25 | 1.01 | 1.46 | 1.19 | 1.20 | .87 | .79 | .64 | 12.16 |
| Snow |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Fraser |  |  |  |  |  |  |  |  |  |  |  |  |  |
| cm | 58.7 | 45.0 | 54.9 | 37.1 | 7.6 | T | 0 | 0 | 0 | 15.5 | 34.0 | 34.3 | 287.0 |
| [in.] | 23.1 | 17.7 | 21.6 | 14.6 | 3.0 | T | 0 | 0 | 0 | 6.1 | 13.4 | 13.5 | 113.0 |

Source: Decennial Census of United States Climate.

## Table 4. FREEZE DATA
## GRAND LAKE (6 SSW)

| Freeze threshold temperature °C | [°F] | Mean date of last spring occurrence | Mean date of first fall occurrence | Mean number of days between dates |
|---|---|---|---|---|
| 0 | 32 | 19 Jun | 30 Jul | 41 |
| -2.2 | 28 | 5 Jun | 14 Sep | 101 |
| -4.4 | 24 | 13 May | 27 Sep | 137 |
| -6.7 | 20 | 3 May | 8 Oct | 158 |
| -8.9 | 16 | 26 Apr | 23 Oct | 180 |

Source: Decennial Census of United States Climate.

## Table 5. MEAN NUMBER OF DAYS WITH TEMPERATURE ≤ 0°C [32°F]
## GRAND LAKE (6 SSW)

| Mean number days with temperature ≤ 0°C [32°F] | | | | | | | | | | | | Annual mean temperature | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | ≤ 0°C [32°F] | > 0°C [32°F] |
| 31 | 28 | 31 | 29 | 23 | 7 | 1 | 1 | 15 | 27 | 29 | 31 | 253 | 112 |

Source: Decennial Census of United States Climate.

mer temperatures, is the major factor causing this high evaporative stress. A comparison of precipitation and evaporation data for Granby is shown on Figure 5. It is clear that evaporation far exceeds precipitation for the five months May through September.

## Topography

While the developed portions of the planning area are flat or gently rolling, most of the terrain is mountainous, with steep slopes. Elevations range from about 2,396 m [7,860 ft]* near Windy Gap to 2,951 m [9,681 ft] atop Ninemile Mountain at the southeastern boundary of the area. The flatter portions of the study area are at an average elevation of about 2,440 m [8,000 ft]. The town of Granby is at elevation 2,418 m [7,935 ft]. Elevation variations in the southern portion of the planning area are shown on Figure 2. The Fraser and Colorado rivers and their tributaries, originating mainly within the study area, have carved gentle, wide valleys into the landscape and provide a unique topography.

Slopes in the vicinity of the town of Granby range from 3 to 15 percent, while in other parts they vary from 0 to 65 percent.

## Geology

It is generally believed that the Rocky Mountains, including the Colorado Front Range, Park Range and southern Laramie Mountains, were created more than 60 million years ago by tremendous uplifting forces (References 8 and 9). From that period onward, the erosive and leveling forces of weathering have separated and carried soluble materials and those easily suspended in stream waters to lower elevations. The high, mostly granitic mountains in the area have been sharply sculptured by glacial action, forming steep canyon walls, precipitous, rocky slopes and U-shaped valleys. The intermountain valleys have been filled with sediments carried by the streams and glaciers from the surrounding mountains.

Middle Park is the southern half of a synclinal basin, separated from the northern half by the Rabbit Ears Range. Two sets of overthrust faults traverse Middle Park, dividing it into distinct geologic and topographic units (Reference 8). The floor of the basin is covered by Mesozoic and Tertiary sedimentary rocks which are underlain and flanked by Precambrian igneous rocks.

It is surmised from published data (References 9, 10, 11 and 12) that the faults in the vicinity of the planning area are not active. Throughout historical times, only one earthquake of damaging proportions has been reported in Colorado, near Denver (Reference 18).

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*Elevations given are U.S.G.S. data with reference to mean sea level. Official U.S.G.S. elevations are in English units, shwon in brackets.

The geology of the planning area has been described by Lovering (Reference 9), who discovered the Granby Anticline in 1928, and Sanders (Reference 10). The Granby Anticline, a geological structure important in the area, is a narrow fold with its north-south axis along the western parts of the study area. Surface distribution of the rocks and a cross section along the southern part of the study area are portrayed in Figure 6 and Table 6, respectively.

The oldest rocks in the planning area are crystalline pre-Cambrian rocks, exposed in the southeastern part of the area and buried to depths of more than 1,500 m [5,000 ft] in the central and northern parts. They are comprised of horneblende gneiss and biotite-sillimanite schist with pink biotite granitic intrusions.

The pre-Cambrian schist, gneiss and granite are overlain by beds of gray and maroon shale and light-gray sandstone. These layers are about 55 m [175 ft] thick and are covered by a Conglomeratic sandstone 5 to 8 m [15 to 25 ft] thick. These rocks are overlain successively by an interbedded layer of shale and a white quartzite sandstone about 24 m [80 ft] thick.

Scattered outcrops of black Marine Cretaceous shale beds, of Benton, Niobrara and early Pierre age, are found in various parts of the study area in different thicknesses. A sandy unit, Marine Cretaceous sandstone, overlies the black shale. The sandy unit includes, from the base upward, about 30 m [100 ft] of interbedded sandy shale, shaly sand, shaly sandstone and limy sandstone, followed by about 90 m [300 ft] of dark sandy shale and some lignitic shale.

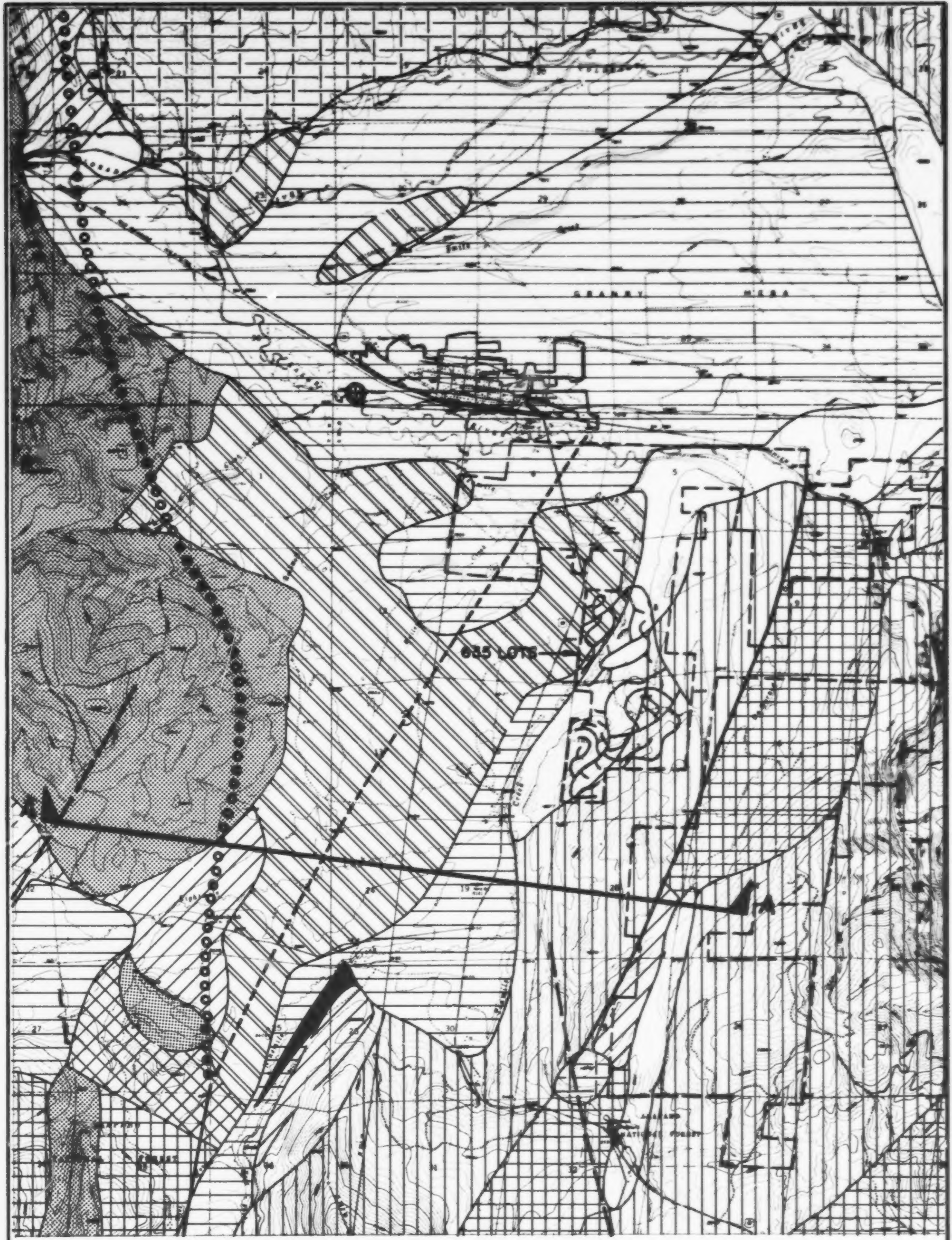
The terraces near Granby are formed of outwash gravel from Pleistocene glaciers of Quarternary age. South of Granby, a formation of grayish-white clay and brown conglomerate covers the surface. This material is estimated to have been deposited between the time of the Eocene Middle Park formation (60 million years ago) and that of beds of Miocene age (25 million years ago). These formations essentially comprise the water-bearing strata in the study area.

## Soils

The environmental implications of soil properties in an area are many; they include agricultural fertility, ecological productivity, hydrologic characteristics, vegetative associations, erosion hazards, foundation properties, frost-heave potential, waste assimilation and/or purification properties, shrink-swell behavior, corrosivity and resource value (sand, gravel, fill, topsoil, etc.). Hence, the soils of the Granby area were evaluated so that their limitations from various environmental viewpoints could be recognized.

Occurrence of various soil types within the Granby quadrangle is

FIGURE 6

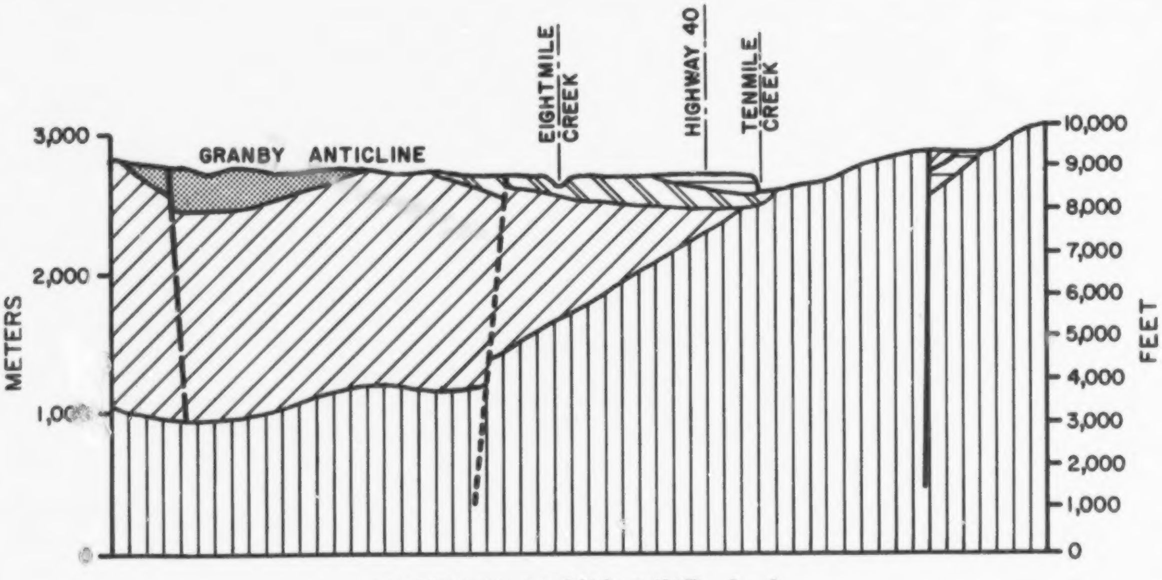

GRANBY MESA
685 LOTS
A
A'

GEOLOGY OF THE GRANBY QUADRANGLE
(FOR LEGEND SEE TABLE 6)

## Table 6. LEGEND FOR FIGURE 6.

| | | | | |
|---|---|---|---|---|
| QUATERNARY | ▤ | ALLUVIUM AND TERRACE GRAVEL | -·—·—·- | FAULT LINE |
| TERTIARY | ▦ | INTERBEDDED BASALT ANDESITE, AND CONGLOMERATE CONTAINING ARIKAREE VERTEBRATES | ooooooooo | GRANBY ANTICLINE AXIS |
| | ▧ | WHITE RIVER GROUP CLAY AND CONGLOMERATE | ——— | BOUNDARY OF GRANBY SANITATION DISTRICT |
| | ◢ | DIORITE PORPHYRE INTRUSIVES | - - - - - - | BOUNDARY OF VAL MORITZ RESIDENTIAL DEVELOPMENT |
| | ▩ | MIDDLE PARK FORMATION | ◍ | EXISTING WASTEWATER TREATMENT PLANT SITE |
| | ▒ | MIDDLE PARK FORMATION VOLCANIC BRECCIA AT BASE | | |
| CRETACEOUS | ▨ | MARINE CRETACEOUS SHALE | | |
| | □ | CRETACEOUS SANDSTONE AND SHALE | | |
| PRE-CAMBRIAN | ▥ | SCHIST, GNEISS AND GRANITE | | |
| | ▦ | UNMAPPED AREA | | |

SOURCE: ADAPTED FROM U.S.G.S. BULLETIN 822-B


EIGHTMILE CREEK
HIGHWAY 40
TENMILE CREEK
GRANBY ANTICLINE
3,000
2,000
1,000
0
METERS
10,000
9,000
8,000
7,000
6,000
5,000
4,000
3,000
2,000
1,000
0
FEET

SECTION ALONG LINE A-A

shown on Figure 7. Symbols used in this map are correlated with soil names and characteristics discussed in Appendix A. Most soils in the planning area are severely limited for use of septic tank leach fields and sewage lagoons. Many areas, on the other hand, are suitable for land application of wastewater effluent. Most soils in proposed development areas are readily erodible. Generally, soils in the Granby area are not of prime importance for agricultural production. A more detailed discussion of soils is presented in Appendix A.

## Water

The Granby planning area is contained within the Fraser hydrologic sub-basin of the Colorado River Basin. The Colorado River headwaters, in the Fraser sub-basin, are in the Front Range Mountains, bounded by the Continental Divide and mostly within Rocky Mountain National Park. The river and its tributaries discharge some 380 million cu m [~310,000 ac ft] per year into the Three Lakes System (Grand Lake, Shadow Mountain Reservoir and Lake Granby). A minimum flow of 1.42 cu m per sec [50 cfs] is discharged from Lake Granby through Granby Dam. About 30 million cu m [240,000 ac ft] per year is diverted from the Three Lakes System for transfer to the eastern side of the Rockies by the Northern Colorado Water Conservancy Districts (Reference 13).

The Colorado River is joined by the Fraser River about 6 km [4 miles] west of Granby. The Fraser River flows north from the Williams Fork Mountains, whose high elevations (over 4,000 m [13,000 ft]) and precipitous glaciated slopes form its watershed.

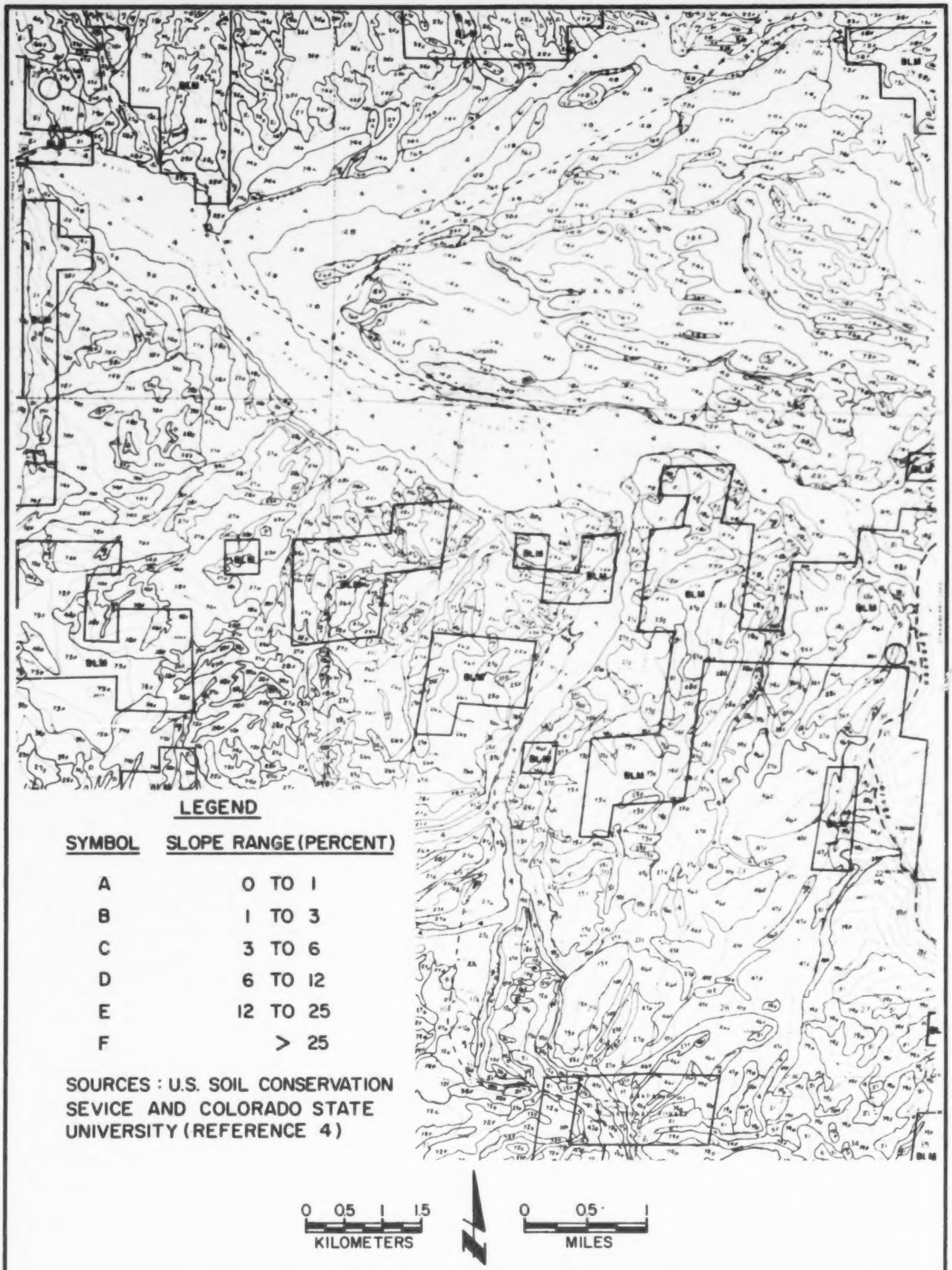
The Fraser River is fed by runoff and snowmelt from a 738 sq km [285 sq mile] drainage basin. Flows in the Colorado River and the Fraser River are generally highest in May and June following snow melt in the mountains. Lowest flows occur during the winter months, when there is very limited runoff. Diversions from the river for irrigation also create a low-flow period during August-September. Surface water quality is generally good and supports abundant fish life.

Groundwater availability is highly variable in the study area. Many springs emerge at seemingly random locations, and in other areas the depth to groundwater is about 45 m [150 ft]. Groundwater quality is generally very good, suitable for drinking, except in spot locations where it is influenced by septic tank leach fields and in other areas where iron and manganese dissolved from natural formations impair quality.

### Water Quality--

Colorado River. Water quality has been monitored at Hot Sulphur Springs on the Colorado River about 16 km [10 miles] downstream of the confluence with the Fraser River. Data for some constituents is available beginning in 1947. Dissolved oxygen data are presented in Table 7.

FIGURE 7


BLM
0 0.5 1 1.5
KILOMETERS
0 0.5 1
MILES

**LEGEND**

| SYMBOL | SLOPE RANGE (PERCENT) |
|---|---|
| A | 0 TO 1 |
| B | 1 TO 3 |
| C | 3 TO 6 |
| D | 6 TO 12 |
| E | 12 TO 25 |
| F | > 25 |

SOURCES : U.S. SOIL CONSERVATION SEVICE AND COLORADO STATE UNIVERSITY (REFERENCE 4)

SOIL SERIES AND SLOPES IN GRANBY QUADRANGLE

Table 7. DISSOLVED OXYGEN AND TEMPERATURE DATA FOR THE COLORADO RIVER AT HOT SULPHUR SPRINGS

| | Dissolved oxygen, mg/l | | | | Temperature, °C | | | |
|---|---|---|---|---|---|---|---|---|
| Month | Number of samples | Mean | Minimum | Maximum | Number of samples | Mean | Minimum | Maximum |
| Jan | 3 | 7.8 | 7.5 | 8.1 | 5 | 0 | 0 | 0 |
| Feb | 2 | 6.4 | 6.1 | 7.2 | 3 | 0 | 0 | 0 |
| Mar | 3 | 10.0 | 7.0 | 11.0 | 4 | 0 | 0 | 1.1 |
| Apr | 3 | 9.0 | 6.5 | 10.0 | 4 | 4.4 | 0 | 8.9 |
| May | 4 | 8.8 | 3.1 | 15.0 | 4 | 9.4 | 2.8 | 13 |
| Jun | 4 | 7.5 | 6.0 | 10.0 | 4 | 10 | 6.7 | 12 |
| Jul | 3 | 7.0 | 4.0 | 9.2 | 4 | 17 | 14 | 20 |
| Aug | 4 | 7.5 | 6.0 | 9.2 | 4 | 17 | 13 | 19 |
| Sep | 3 | 9.0 | 5.0 | 12.0 | 3 | 16 | 12 | 18 |
| Oct | 5 | 8.8 | 7.2 | 10.6 | 5 | 7.2 | 2.2 | 10 |
| Nov | 5 | 8.5 | 10.2 | 5.6 | 5 | 0 | 0 | 0.56 |
| Dec | 1 | 10.1 | 10.1 | 10.1 | 2 | 0 | 0 | 0 |

Source: Adapted from Colorado River Basin Water Quality Management Plan.

Dissolved oxygen is higher in the fall and spring and is lower during the low-flow period of January-February and the warmer summer months of June-August. Water temperature data are also shown in Table 7. Water temperature is near freezing during five months of the year and approaches mean air temperature during the summer.

Total phosphates in the Colorado River at this location have averaged 0.1 mg/l, with a range of zero to 0.5 mg/l. Nitrate nitrogen has averaged 0.1 mg/l, with a range of zero to 0.8 mg/l, and ammonia nitrogen has averaged 0.12 mg/l, with a range of zero to 0.7 mg/l. Fecal coliform bacteria concentrations have averaged 930 MPN per 100 ml, with a range of 2 to 24,800 MPN per 100 ml. According to USGS (Reference 14), total dissolved solids have ranged from 38 mg/l to 167 mg/l. All of these constituents are generally higher in concentration during the low-flow periods of January-February and more dilute during the snowmelt period of May-June. This would indicate an external source of contamination unrelated to natural runoff. According to the Colorado River Basin Plan (Reference 2), pH is relatively high and has ranged from 7.3 to 9.4 during the period 1968-1973; however, according to USGS (Reference 14), pH during 1969 ranged from 6.3 to 7.8, a more normal range.

Fraser River. There are currently no water quality monitoring stations on the Fraser River. A wasteload allocation study was conducted in 1973 (Reference 15) in which data were collected on four days in August at various stations along the river. Results of the sampling program for stations within the study area are shown in Table 8. Dissolved oxygen was nearly always above the saturation level and ranged from 7.1 to 9.1 mg/l. Phosphates were always less than 0.1 mg/l. Ammonia-nitrogen varied from less than 0.1 mg/l to 1.8 mg/l. Biochemical oxygen demand varied from 0.9 to 3.8 mg/l, and fecal coliform varied from 3 to 50 MPN per 100 ml. The concentrations of all of these nutrients and bacteria are generally low, but the variability of the data allows few conclusions to be drawn. More data of this type are needed in order to characterize the seasonality of water quality and determine fully the impact of wastewater discharges.

### Water Quantity--

Colorado River. Measurements of river discharge have been made on the Colorado River at Hot Sulphur Springs since 1905 and at a station near Granby, upstream of the confluence with the Fraser River, since 1908. Measurements for the period 1905/1908 through 1949 reflect the unregulated, natural flows of the river prior to the Big Thompson Project. After the completion of that project in 1950, flows on the Colorado became highly regulated. Flows were reduced during 1951 through 1958 while water was being collected for the 23 million cu m [18,369 ac ft] Shadow Mountain Reservoir, the 181 million cu m [146,900 ac ft] Green Mountain Reservoir, the 1.4 million cu m [11,177 ac ft] Willow Creek Reservoir and the 666 million cu m [539,758 ac ft] Lake Granby Reservoir.

Design low flows were estimated in the Colorado River Basin Water Quality Management Plan (Reference 2). The period 1962 through 1972 was analyzed. For the purpose of water quality analysis, the August-September 1956 seven-day low-flow average was selected as the design flow for determining impact of waste loads on the Colorado River. The design low flow in the Colorado River above the confluence of the Fraser River is 0.4 cms [14 cfs]. Downstream, at Hot Sulphur Springs, the flow is nearly one cms [35 cfs]; this higher flow reflects principally the runoff from the Fraser River.

Because of the construction of upstream reservoirs, flood flows on the Colorado upstream of the Fraser River have been greatly attenuated. In the period before 1949, maximum daily discharges of 85 cms [3,000 cfs] had been observed. After 1959 the largest annual peak discharge was 40 cms [1,420 cfs], on 3 July 1962 (Reference 16). Downstream of the Fraser River confluence at Hot Sulphur Springs, the Colorado River flood peaks are closely related to the Fraser River flood

## Table 8. WATER QUALITY DATA FOR THE FRASER RIVER

| | East of Highway 40 0.7 miles on dirt road Elevation 7,981 ft; river miles above mouth, 5.18 | | | | Highway 40 bridge south of Granby Elevation 7,951 ft; river miles above mouth, 4.16 | | | | Bridge on road to Granby Sewage Treatment Plant Elevation 7,894 ft; river miles above mouth, 2.31 | | | | Above Colorado River Elevation 7,837 ft; river miles above mouth, 0.04 | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Parameters | Aug.6[a] 3:40p | Aug.11 11:25a | Aug.22 9:15a | Aug.24 1:10p | Aug.6 3:20p | Aug.13 1:55p | Aug.23 7:15a | Aug.24 1:20p | Aug.6 3:10p | Aug.14 7:45a | Aug.22 10:30a | Aug.28 7:45a | Aug.8 7:20a | Aug.13 2:15p | Aug.22 9:35a | Aug.24 1:30p | Aug.29 9:50p |
| Dissolved oxygen, mg/l | 8.0 | 7.5 | 8.4 | 8.2 | 8.0 | 7.1 | 8.9 | 7.5 | 7.4 | 7.5 | 80 | 9.1 | 8.5 | 8.6 | 87 | 82 | 71 |
| Temperature, °C | 16.0 | 15.0 | 14.0 | 16.5 | 16.0 | 17.5 | 11.5 | 17.5 | 18.0 | 12.0 | 15.0 | 12.0 | 12.5 | 19.0 | 140 | 17.5 | 160 |
| Suspended solids, mg/l | 4.0 | 4.2 | 19.0 | 4.2 | <1 | 5.6 | 7.3 | 7.6 | 4.0 | 7.2 | 10.0 | 4.0 | 2.0 | 7.2 | 15.0 | 30 | 88 |
| Dissolved solids, mg/l | 61 | 71 | 124 | 66 | 60 | 51 | 33 | 17 | 83 | 104 | 100 | 81 | 92 | 61 | 91 | 33 | 64 |
| pH | 8.0 | 7.9 | 7.2 | 7.6 | 8.0 | 8.0 | 7.5 | 7.7 | 7.9 | 7.7 | 78 | 75 | 74 | 84 | 77 | 77 | 80 |
| Chloride, mg/l | 6.7 | 6.7 | 11.0 | 14.0 | 10.0 | 5.0 | 13.0 | 10.0 | 10.0 | 8.4 | 13.0 | 16.0 | 13.0 | 5.0 | 12.0 | 12.0 | 15.0 |
| Phosphate, mg/l | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <1.0 |
| Nitrate-nitrogen, mg/l | 0.05 | 0.06 | 0.3 | 0.16 | 0.15 | 0.08 | 0.18 | 0.25 | 0.11 | 0.05 | 0.4 | 0.2 | <0.01 | 0.08 | <0.1 | 0.41 | <1.0 |
| Ammonia-nitrogen, mg/l | 0.7 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | 0.6 | 1.1 | 0.5 | <0.1 | 0.3 | 0.5 | <0.1 | <0.1 | <0.1 | 1.8 | 0.1 |
| Sp. conductance, μmho/cm | 86 | 84 | 126 | 83 | 89 | 100 | 93 | 83 | 108 | 110 | 104 | 104 | 100 | 110 | 100 | 110 | 102 |
| Turbidity, JTU | 6 | 2 | 8 | 4 | 6 | 2 | 3 | 5 | 5 | 3 | 4 | 4 | 4 | 2 | 3 | 4 | 3 |
| 5-day BOD, mg/l | 2.4 | 2.1 | 1.0 | 0.9 | 1.9 | 2.9 | 2.1 | 1.1 | 2.9 | 2.9 | 2.7 | 1.3 | 28 | 3.8 | 21 | 0.9 | 1.7 |
| Total coliforms, per 100 ml | 45 | 45 | 45 | 60 | 35 | 25 | 40 | 75 | 45 | 45 | 15 | 95 | 35 | 25 | 25 | 85 | 20 |
| Fecal coliforms, 100 ml | 15 | 15 | 10 | 25 | 10 | 15 | 35 | 35 | 20 | 15 | 3 | 50 | 10 | 10 | 5 | 40 | 10 |
| Discharge, cfs | 122 | 110 | 80 | 76 | 125 | 73 | 82 | 78 | 134 | 80 | 875 | 76 | 136 | 85 | 88 | 84 | - |
| Average velocity, ft/sec | 1.80 | 1.60 | 1.40 | 1.30 | 1.90 | 1.50 | 1.40 | 1.30 | 200 | 1.40 | 1.50 | 1.40 | 200 | 1.50 | 1.50 | 1.40 | - |
| Hydraulic mean depth, ft | 1.20 | 1.20 | 1.10 | 1.20 | 1.40 | 1.30 | 1.30 | 1.40 | 1.70 | 1.50 | 1.60 | 1.50 | 1.80 | 1.60 | 1.60 | 1.50 | - |

[a] All dates are for 1973.

Source: Colorado River Basin Plan.

peaks. For the period 1950 to 1962, the annual maximum daily discharge has varied from 24 cms [832 cfs] on 28 June 1959 to 106 cms [3,750 cfs] on 8 June 1952. Clearly the high flows are related to the timing of the snowmelt; over the period 1905-1962, the largest daily discharge during the year has always been in May or June. Peak flood stages for this location are on the order of 0.6 to one meter [2 to 3.5 ft], as measured on the stream gage during the peak runoff periods. However, the highest backwater also occurs here due to ice in the river. A stage of 1.7 m [5.5 ft] was recorded on 22 November 1961.

Fraser River. Measurements of river discharge on the Fraser River at Granby have been made since 1905 except during the period 1910 to 1938. Flows from the river are not regulated; however, diversions for about 3,200 hectares [8,000 acres] of irrigated land have been made upstream of Granby. Since 1937, diversions have also been made to the Moffat water tunnel (Reference 16).

The average discharge for 28 years of record at Granby is 5.6 cms [196 cfs or 141,900 ac ft per year], including all diversions.

The maximum recorded discharge is 70 cms [2,500 cfs], measured on 8 June 1952. The bankfull stage or flood stage is 0.91 m [3 ft]. A further discussion of the flood hazards relative to proposed treatment plant sites is provided in a subsequent section.

### Problems of Water Quality and Quantity--

As stated earlier, water quality in the Colorado and Fraser rivers where they flow through the study area is good. On the average, the water meets the Colorado Water Quality Standards for Class B1 waters (see Table 9). A discussion of these standards and of other laws and regulations related to water quality is presented in Section IV. The quality of Colorado River water occasionally has failed to meet fecal coliform and dissolved oxygen standards. Water quality data for the Fraser River are too limited to allow generalization about whether or not standards are met. On the four days in August 1973 when the water was sampled (see Table 8), the water did meet the Class B1 standards for all parameters.

Water quantity problems are mainly associated with drought or low flows and with floods. Hazards to the study area from floods are discussed under a separate heading, below.

The low flows in the Fraser and Colorado rivers have been used to establish standards for the discharge of treated effluent. Results of the analysis of the water quality problem presented in the Basin Plan (Reference 2) show that secondary treatment plus nitrification to remove ammonia and a disinfection method that does not increase effluent toxicity will be required for the proposed discharge in order to meet water

Table 9. CLASS B1 WATER QUALITY STANDARDS FOR THE COLORADO RIVER ABOVE SULPHUR SPRINGS AND THE FRASER RIVER

| Parameter | Standard |
|---|---|
| Settleable solids | free from |
| Floating solids | free from |
| Taste, odor, color | free from |
| Toxic materials | free from |
| Oil and grease | cannot cause a film or other discoloration |
| Radioactive material | drinking water standards |
| Fecal coliform bacteria | geometric mean of < 1,000/100 ml from five samples in 30-day period |
| Turbidity | no increase of more than 10 J.T.U. |
| Dissolved oxygen | 6 mg/l minimum |
| pH | 6.0 - 9.0 |
| Temperature | maximum 20°C [68°F], maximum change 1°C [2°F] |
| Fecal streptococcus | -- |

Source: Colorado State Department of Health.

quality standards at the 10-year, 7-day low flow. It should be noted that there is a potential for further water diversions out of the headwaters of the Fraser River by eastern slope communities. If and when this further diversion takes place, any water quantity problems of the Fraser River could possibly be compounded.

### Water Quality Management--

Water quality management involves the protection of water quality and existing and potential water uses from the adverse effects of wastewater and nonpoint discharges.

Water quality management includes the control of nonpoint pollution (erosion and resulting sedimentation) that results from land disturbance. Those direct land-use changes from the proposed project, such as sewer line and treatment plant construction, and those secondary changes, such as provision of sewer service (thus encouragement of land development in a particular area that may result in sediment and nutrients entering stream courses), are of concern to EPA in its facilities planning and review process.

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All of the alternative wastewater management systems proposed in the Facilities Plan have been designed to meet all applicable standards. Discussion of the effects of proposed discharges upon water quality is found in Section IV.

The Grand County Board of Health resolution pertaining to individual sewage disposal systems (Reference 17) is an effective tool in the management of water quality in the study area. Promulgation and enforcement of land-use regulations governing erosion control and other nonpoint sources of pollution probably have not been as stringent as they should be to protect the quality waters of the area. This is an aspect of local land-use policy that EPA believes to be critical to environmental quality control.

Water Use--

The principal use of the Colorado and Fraser rivers within the study area is for domestic purposes, irrigation, recreation, fishing and treated wastewater assimilation. Water supply for the Granby area is met by pumpage from the Fraser River just west of the Highway 40 bridge across the river. A new high-pressure filter plant treats almost 3,800 cu m per day [one mgd] for domestic water supply. Objectionable odors during the summer months are reported (Reference 18) and are attributed to algal growth in the river at this time of year (References 19 and 20). Chemical and biological characteristics of served water, shown on Table 8, meet established drinking water quality standards. In the past, nearly all municipal water was supplied from local groundwater sources. However, corrosion of well casings and screens and high iron and manganese content of supplied water were commonly encountered problems (Reference 20). Groundwater is now used merely to supplement the surface water source.

Both upstream and downstream of the study area, the rivers are used for municipal water supply, irrigation, recreation and assimilation of treated wastewaters. Of great concern to water users downstream of the study area is the increasing total dissolved solids concentrations and other degradation caused by each use cycle.

Fishing on the Fraser River is of traditional and historic significance in addition to its recreational value.

Flood Hazards--

The study area includes the drainage courses of two major rivers. Because the Colorado River is regulated by Lake Granby, there is virtually no flood hazard on the Colorado River upstream of its confluence with the Fraser. The Fraser is also regulated by substantial water diversion projects administered and controlled by the Denver Water Board for water transfer of the City and County of Denver. However, there are some flood hazards presented by the Fraser River because runoff from its 738 sq km [285 sq mile] drainage area is not totally regulated.

A frequency diagram for the Fraser River at Granby was computed and is shown in Figure 8. The data used for the frequency analysis were the maximum daily discharges occurring in each year for the periods 1905-1909 and 1938-1955. Since that period, additional river regulation has somewhat reduced flood hazards. It is expected that the U.S. Army Corps of Engineers will soon be conducting a flood hazard study on the Fraser River in the vicinity of Granby.

An analysis was made of the pre-1955 flood conditions in the Fraser River at Granby. From velocity, discharge, hydraulic depth and elevation data, presented in the last three rows in Table 8, it was surmised that the channel had a Manning's roughness coefficient of 0.070. Furthermore, it is noted (Reference 16) that the river has a bankfull stage of 0.91 m [3 ft]. For the 50-year flood, the actual stage, measured on 8 June 1952, was 1.11 m [3.65 ft]. To carry this flow, a channel 60 m [200 ft] wide would be required, according to computations using the USGS stage discharge relationship. From inspection of the topographic maps showing river channels, it is apparent that the river would actually have four main channels to carry the 50-year flood and would flood the area between the channels. The stage information was converted to elevation, and the estimated 50-year flood plain was mapped as shown on Figure 9. The map was verified and supplemented by similar information developed at Colorado State University (Reference 27).

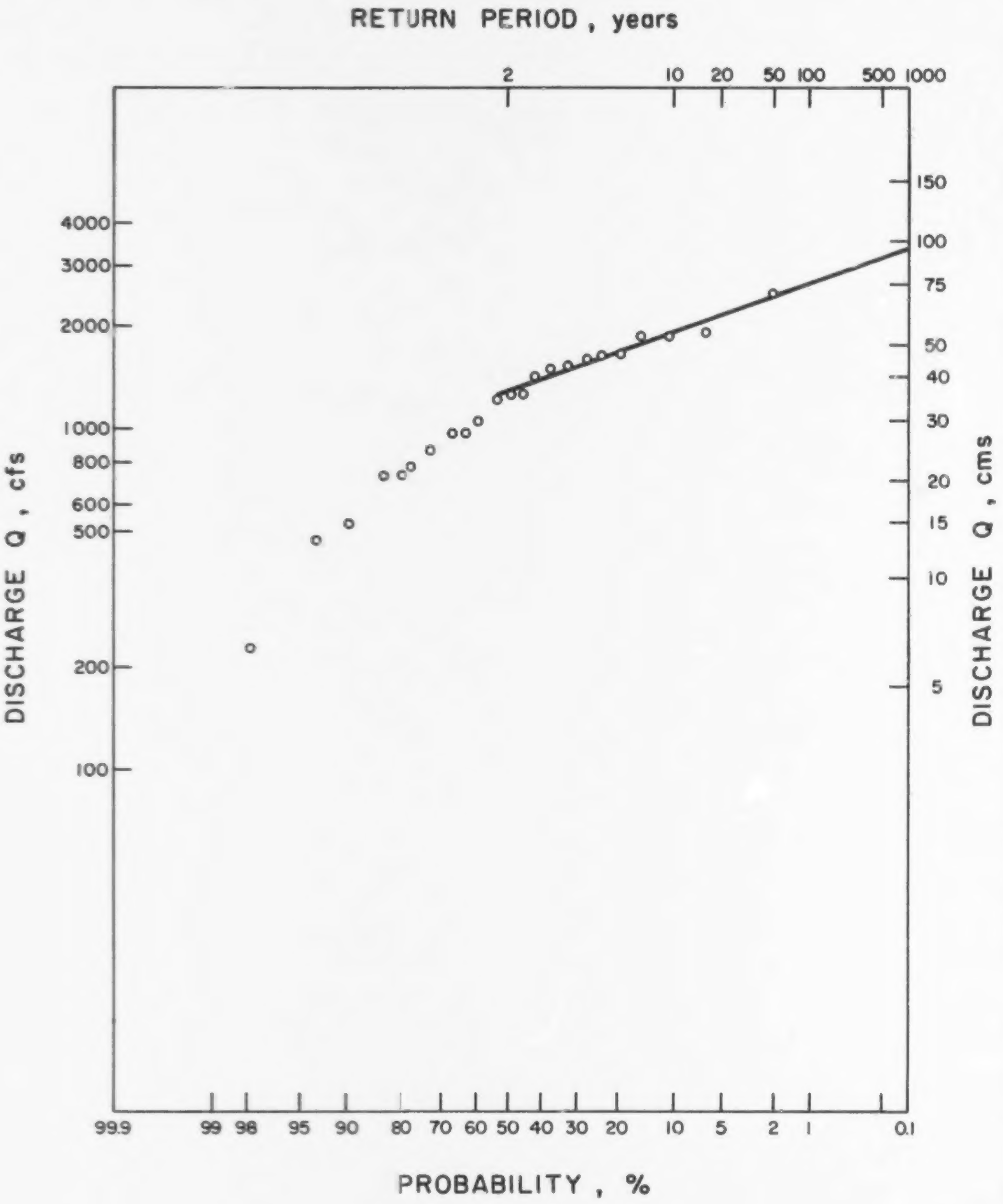
The location of the existing and proposed treatment plant sites, shown on Figure 10, is clearly such that the existing sites as well as proposed sites 1 and 4 are within the flood plain. Sites 2 and 3 could easily be protected by levees for added safety. Site 5 is completely out of and away from the flood plain.

Groundwater--

The more important water-bearing strata in the planning area are: young alluvial deposits; Dakota sandstone (Cretaceous sandstone and shale in Figure 6); Leadville limestone and pre-Cambrian crystalline rocks. Complex faults and folds in the area directly affect hydrogeologic conditions and produce highly variable groundwater conditions locally within a given aquifer (Reference 12). The valley fill deposits are the most reliable sources of groundwater and can yield from 0.3 to 60 l/sec [5 to 1,000 gpm] of water to wells.

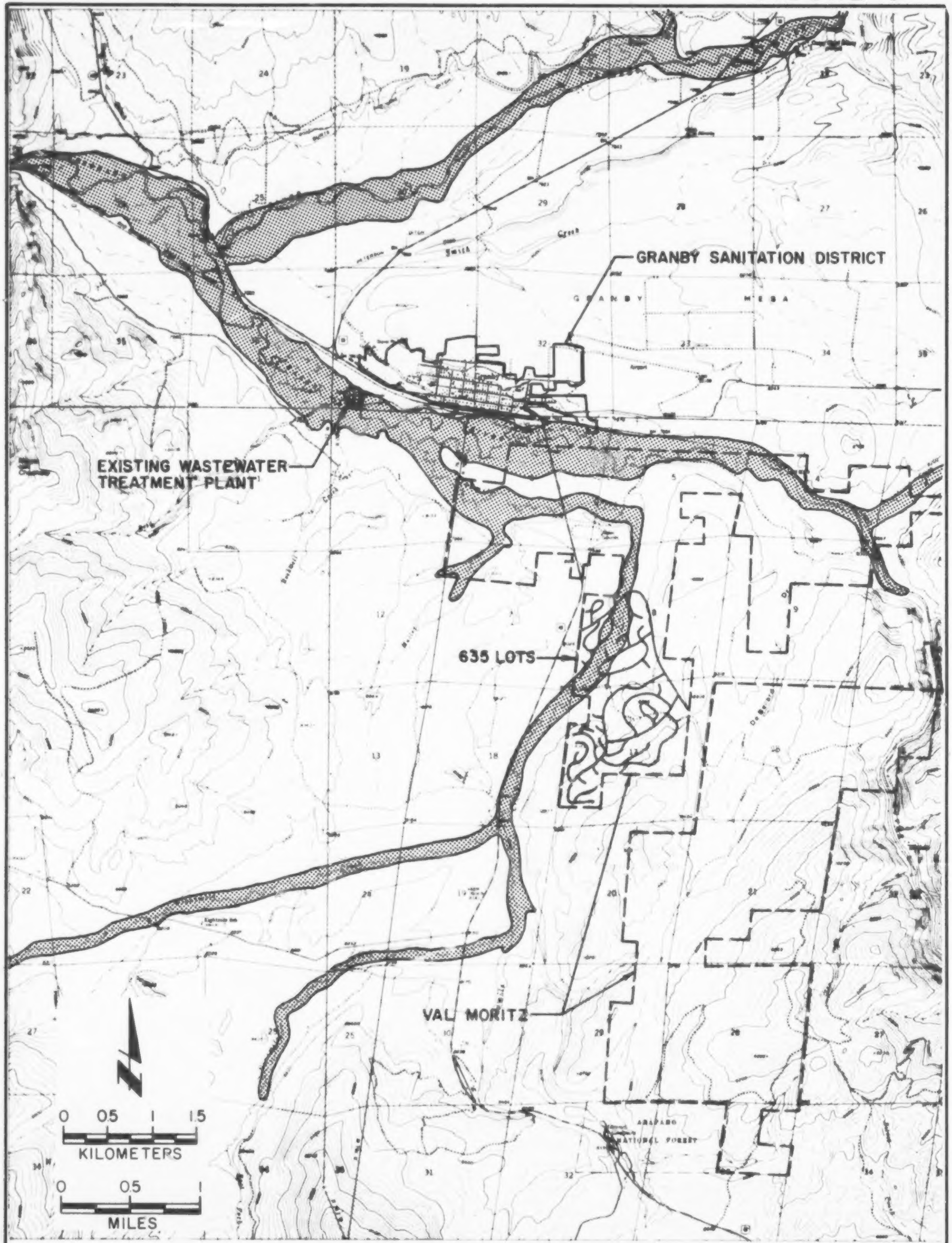
Few published data are available to characterize the quantity and quality of the groundwater in the Granby area. USGS Professional Paper 813-C (Reference 21) contains only general information. In certain areas such as along Garnet Street and Diamond Avenue the groundwater

FIGURE 8



PROBABILITY OF THE ANNUAL MAXIMUM DAILY DISCHARGE
BEING GREATER THAN OR EQUAL TO Q
FRASER RIVER AT GRANBY

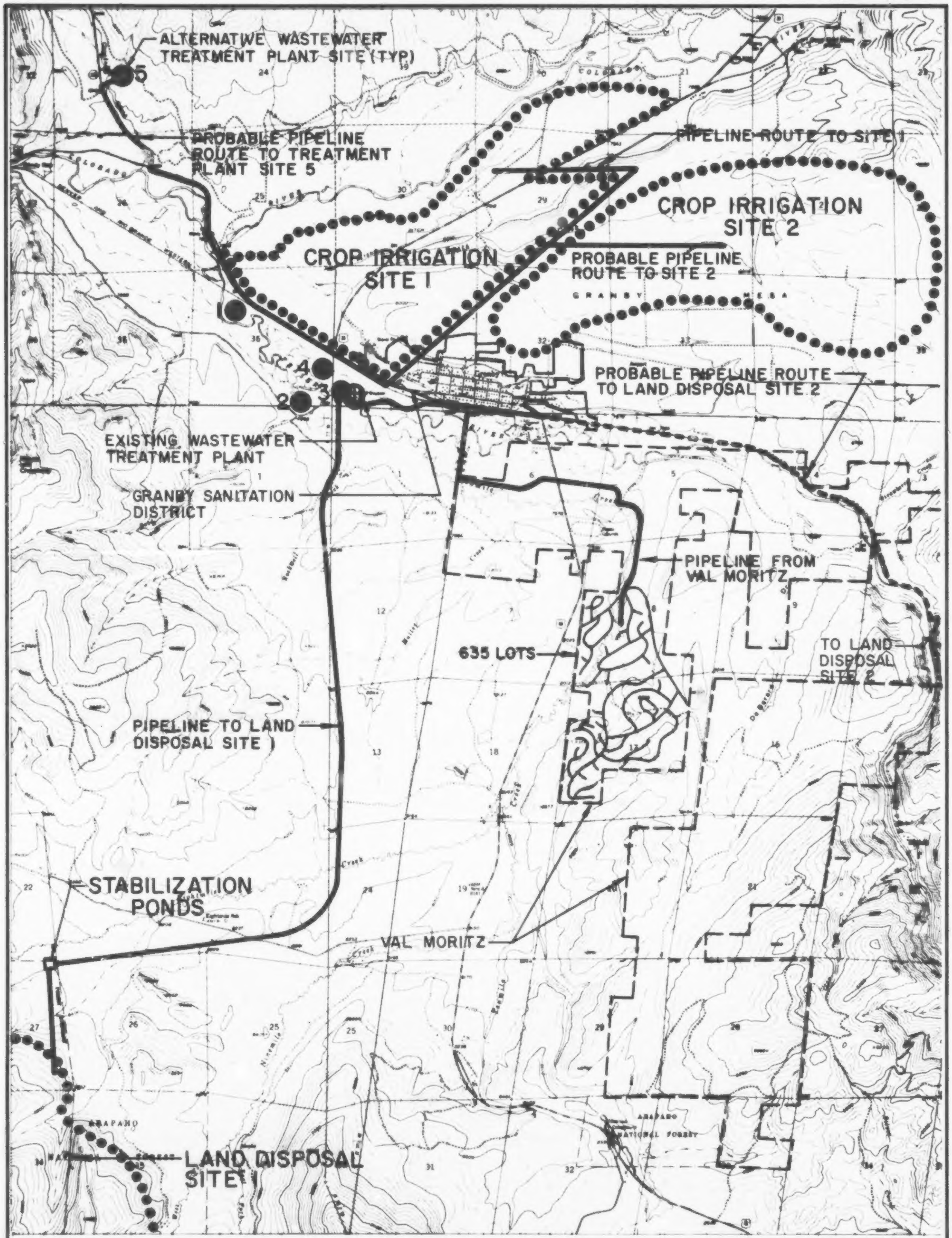
FIGURE 9


GRANBY SANITATION DISTRICT
GRANBY MESA
EXISTING WASTEWATER TREATMENT PLANT
635 LOTS
VAL MORITZ
ARAPAHO NATIONAL FOREST
0 0.5 1 1.5
KILOMETERS
0 0.5 1
MILES

SOURCE : COLORADO STATE UNIVERSITY CARRYING CAPACITY STUDY.

FLOOD PRONE AREAS

FIGURE 10


ALTERNATIVE WASTEWATER TREATMENT PLANT SITE (TYP)
5
PROBABLE PIPELINE ROUTE TO TREATMENT PLANT SITE 5
PIPELINE ROUTE TO SITE 1
CROP IRRIGATION SITE 2
CROP IRRIGATION SITE 1
PROBABLE PIPELINE ROUTE TO SITE 2
GRANBY MESA
1
4
2
3
PROBABLE PIPELINE ROUTE TO LAND DISPOSAL SITE 2
EXISTING WASTEWATER TREATMENT PLANT
GRANBY SANITATION DISTRICT
PIPELINE FROM VAL MORITZ
635 LOTS
TO LAND DISPOSAL SITE 2
PIPELINE TO LAND DISPOSAL SITE 1
STABILIZATION PONDS
VAL MORITZ
ARAPAHO NATIONAL FOREST
LAND DISPOSAL SITE 1
COLORADO RIVER
0 0.5 1 1.5 KILOMETERS
0 0.5 1 MILES

ALTERNATIVE TREATMENT PLANT SITES, ALTERNATIVE PIPELINE ROUTES AND POTENTIAL LOCATIONS FOR CROP IRRIGATION WITH EFFLUENTS emerges as springs during the summer (Reference 22). In other areas such as near Morraine Park the depth to groundwater is more than 26 m [150 ft].

The seasonally high groundwater table level is one of the reasons for the unsuitability of the planning area for the use of septic tank leach fields as a means of on-lot wastewater disposal. Some of the standing water ponds occur in the flatter portions of the planning area to the west of U.S. Highway 40. Qualitative evidence is available to show malfunctioning septic tanks which are probably polluting the groundwater; however, data are presently lacking to document these observations.

Water quality problems in the groundwater supplies arise in part from the geologic formations which comprise the aquifers, introducing various constituents into solution. Iron and manganese have been measured in concentrations exceeding permissible drinking water standards (Fe 0.3 mg/l; Mn 0.05 mg/l) and considerably above desirable drinking water standards (Fe virtually absent; Mn absent). The poor taste of water supplies derived from wells for domestic use in Granby led to the recent change to surface water supplies.

## BIOLOGICAL ENVIRONMENT

### Biotic Communities

The Granby facilities planning area is located within the Middle Park region of the Southern Rocky Mountains. Middle Park is a large, triangular basin defined by the Continental Divide along the north and east and by the Gore Range on the west, as shown in Figure 1. The high mountain ridges on the three sides define regional life forms and populations geographically distinct from adjacent areas. The area around the town of Granby can be characterized as a mountain park, with a topography consisting of relatively level terraces, rolling hills and plateaus and gently rising mountains on the periphery. West of Granby the Fraser River joins the Colorado River. Associated with these watercourses are well-developed valley bottoms and terraces formed by glacial outwash. The elevation ranges from approximately 2,400 m [7,800 ft] to 2,900 m [9,400 ft], thus placing the area within two distinct biotic zones: the upper Montane life zone, occurring between 2,000 m and 2,700 m [7,000 ft and 9,000 ft], and the Subalpine life zone, between 2,700 m and 3,500 m [9,000 ft and 11,500 ft] (Reference 23). These zones are roughly equivalent to the Transition life zone, at 1,800 m to 2,400 m [6,000 ft to 8,000 ft] and the Canadian life zone, at 2,400 m to 3,200 m [8,000 ft to 10,500 ft], referenced in the literature on Colorado flora and fauna (References 24 and 25).

The elevation ranges associated with these life zones are general since local variations in topography and aspect may affect the limitation or extension of characteristic species within and among zones.

The Middle Park region experiences some unique climatic phenomena which contribute to several distinct vegetation patterns and distributions not defined within standard life zone classifications. Winter conditions are often severe, with temperatures dropping to -40°C [-40° F] and strong winds moving through Windy Gap, west of Granby. These factors acting upon the terrain may account for the atypical vegetation patterns found in Middle Park. Absent from the upper Montane and Subalpine life zones of the planning area are the pinyon pine-juniper and scrub oak vegetation communities. In addition, ponderosa pine communities are scarce in the Middle Park region.

The Granby area can be characterized as relatively arid, with an annual precipitation of approximately 37 cm [14 in.], as discussed under Climate.

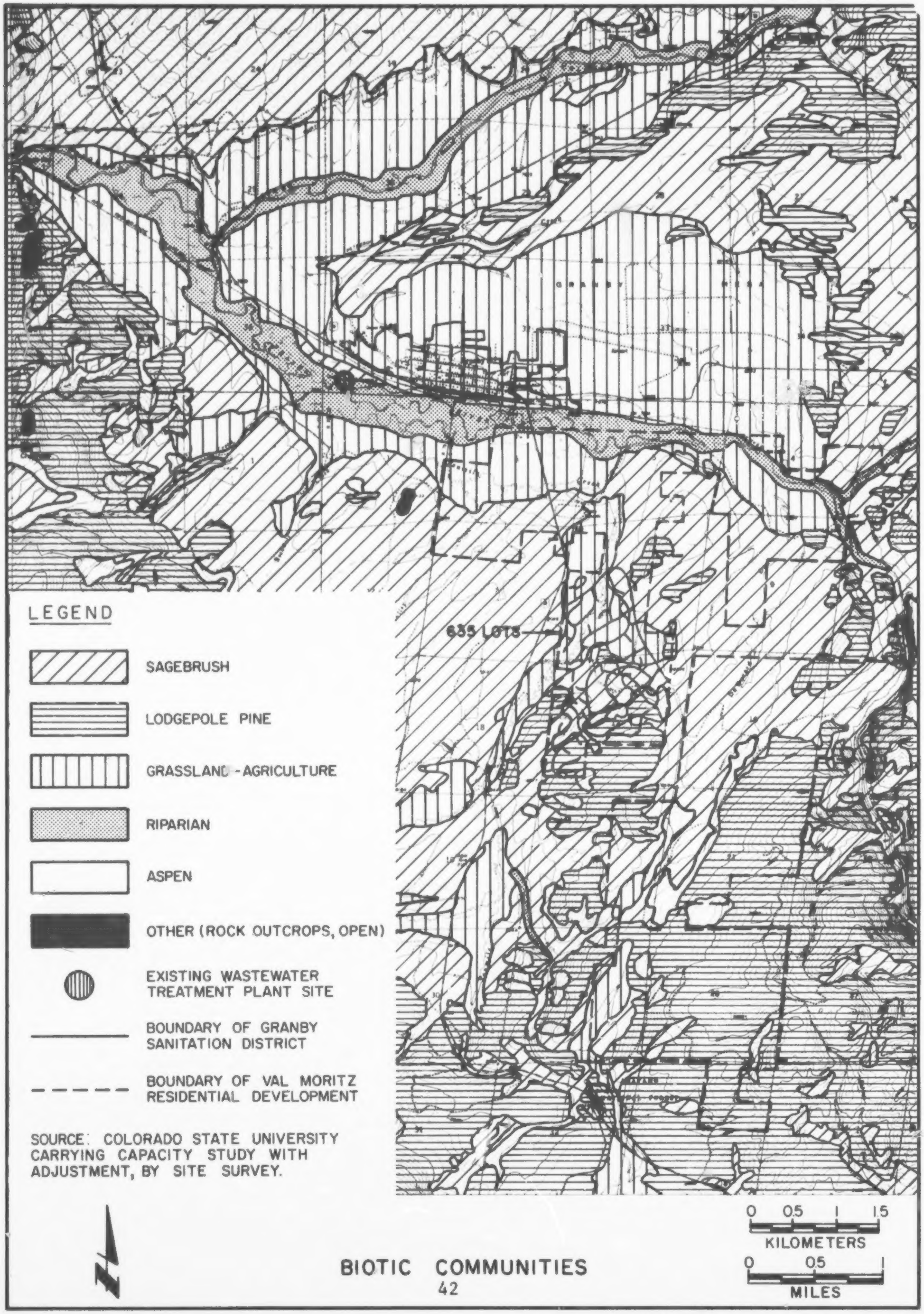
Biotic communities within the Granby area can be categorized as a mosaic of five units, based primarily on vegetation: (1) Sagebrush, (2) Lodgepole Pine, (3) Grassland-Agriculture, (4) Riparian and Aquatic and (5) Aspen. There is some intergrading of species within these units, which should not be viewed as discrete entities. The distribution of these units is largely a function of climate, relief, soil variation and the occurrence of fire, grazing, logging, agriculture and other human activities. Grassland-Agriculture and Sagebrush are the predominant units in the vicinity of Granby. Units of Aspen and Lodgepole Pine generally occur in higher areas with more soil moisture. The general occurrence of the biotic communities is shown in Figure 11. Detailed lists of plant and animal species, scientific nomenclature and occurrence are given in Appendix B. A discussion of the characteristic vegetation and wildlife within the five biotic communities is given in the following sections.

Sagebrush Unit--

Vegetation. Extensive Sagebrush units dominated by big sagebrush occur throughout the planning area, primarily in locations having low soil moisture. Soil conditions and the scarcity of water do not permit larger shrub and tree species to become established. Some authorities believe that many existing sagebrush communities have replaced original grasslands because of human activities such as overgrazing of cattle and fire suppression (References 26 and 27). A land management program involving brush removal and control could convert some sagebrush areas to grasslands. Other major species found in this unit include rabbitbrush, yarrow, dandelion, mule-ears and grasses.

Wildlife. Resident wildlife within the sagebrush habitat is predominantly small rodents and migrant and semi-resident bird species, which include seed-eaters, insect-catchers and several larger birds of prey. Reptiles and amphibians which would normally occur in this dry, desert-like habitat are uncommon due to the adverse winter conditions

FIGURE 11


635 LOTS
GRANBY MESA
LEGEND
SAGEBRUSH
LODGEPOLE PINE
GRASSLAND -AGRICULTURE
RIPARIAN
ASPEN
OTHER (ROCK OUTCROPS, OPEN)
EXISTING WASTEWATER TREATMENT PLANT SITE
BOUNDARY OF GRANBY SANITATION DISTRICT
BOUNDARY OF VAL MORITZ RESIDENTIAL DEVELOPMENT
0 0.5 1 1.5
KILOMETERS
0 0.5 1
MILES

SOURCE: COLORADO STATE UNIVERSITY CARRYING CAPACITY STUDY WITH ADJUSTMENT, BY SITE SURVEY.

BIOTIC COMMUNITIES

associated with high mountain elevations (Reference 28).

Characteristic small mammals include the white-tailed jackrabbit, Richardson's ground squirrel, deer mouse and mountain vole. The most conspicuous animal is the colonial Richardson's ground squirrel, which is often seen characteristically standing upright at the edge of its burrow. Large mammals frequenting sagebrush areas include the mule deer and Rocky Mountain elk. Sagebrush forms a portion of the mule deer diet and is especially important as a winter food supply. On southern slopes, sagebrush areas which border forest ecosystems may be important elk calving areas.

Bird species are most abundant during the spring and summer months. Common small birds include the mountain bluebird, sage thrasher, vesper sparrow, green-tailed towhee and black-billed magpie. A specific occupant of the sagebrush ecosystem is the sage grouse, which does not adapt easily to territorial disturbances. Predator species include the red-tailed hawk and the golden eagle, which are commonly seen soaring over broad, open areas.

### Lodgepole Pine Unit--

Vegetation. Lodgepole Pine units occur throughout the planning area and make up the majority of forested land. Interspersed with Lodgepole Pine are Sagebrush units on lower or drier sites and smaller stands of aspen. Lodgepole is a slow-growing, shallow-rooted tree that is intolerant to shade and grows best on moist, well-drained loams. However, it can also grow in poorly drained areas. It is a pioneer species that reseeds vigorously after wildfires and forms dense stands, with limited species diversity.

At higher elevations, other conifers such as subalpine fir and Englemann spruce are found in greater abundance within Lodgepole Pine units. Lodgepole pine is the chief resource of the subalpine zone, providing material for lumber and other products as well as having watershed maintenance value. The fire potential in Lodgepole Pine units is very high because of its dense growth; this potential is increased on steep slopes. The hardy nature of lodgepole pine makes this ecosystem able to withstand considerable disturbance. Other species found in lodgepole units include aspen, Douglas-fir, bear-berry, huckleberry, fireweed, Colorado blue columbine, harebell and scarlet gilia.

Wildlife. The coniferous forest habitat is specifically preferred by seed-eating mammals such as the golden-mantled ground squirrel, red squirrel and Colorado chipmunk and foraging species such as the porcupine, bushy-tailed woodrat and black bear. The striped skunk and long-tailed weasel also occur in this habitat. The now-endangered gray wolf at one time was probably common throughout this habitat. Urbanization and hunting pressure have almost exterminated the wolf.

Resident birds are mainly insectivorous species such as the red-shafted flicker, hairy woodpecker, downy woodpecker, mountain chickadee and other foraging species which include the gray jay, Clark's nutcracker, blue grouse and pine grosbeak. Larger predator species include the screech owl, great horned owl, golden eagle and red-tailed hawk. Some of the migrant summer inhabitants are the chipping sparrow, gray-headed junco and yellow-rumped warbler (Reference 29).

### Grassland-Agriculture Unit--

Vegetation. Grassland-Agriculture units include areas of irrigated crops, pasture, hay and nonirrigated range and pasture. Increased soil moisture and organic content permit the establishment of a sod-layer that resists invasion by sagebrush and other shrubby plants. Some irrigated hay lands are former sagebrush units that have been converted to viable agricultural lands through sagebrush control and irrigation (Reference 27).

Grassland-Agriculture units generally are found on alluvial terraces and adjacent low-lying lands. These units frequently intergrade with Sagebrush units according to changes in elevation and soils. Major grass species include Thurber fescue, Idaho fescue, timothy, foxtail barley, smooth brome, needlegrass, western wheatgrass and bluegrass. Principal shrub and herbaceous growth generally consists of big sagebrush, rabbitbrush, yarrow, alfalfa, lupine, buckwheat and locoweed.

Wildlife. A large variety of animals is associated with the grassland-agriculture ecosystem, using it primarily as a food source. The most abundant animals are small rodents and mice such as the white-tailed jackrabbit, Richardson's ground squirrel, the deer mouse and the meadow and mountain vole. These form the diet of predator species such as the coyote, long-tailed weasel, sparrow hawk and other large raptors. Other mammals which depend on the grassland-agriculture habitat are the badger, yellow-bellied marmot, striped skunk, mule deer and Rocky Mountain elk.

The grassland-agriculture habitat often is intermingled with sagebrush habitat and shares many of the same bird species. Migrant birds are more abundant in spring and summer and are slightly more diverse than those in Sagebrush because the grassland areas border the woodlands. Common species occurring in the grasslands are the mountain bluebird, Brewer's blackbird, Brewer's sparrow, the horned lark, black-billed magpie, raven and lark bunting. The lark bunting is the official Colorado state bird. Farmland areas and pasturelands are generally favored by the western meadowlark, robin, brown-headed cowbird, vesper sparrow and common crow (References 30 and 31).

Riparian and Aquatic Unit--

Vegetation. Riparian vegetation occurs along rivers, streams, ponds and lakes within the planning area. The larger rivers and streams that have a continuous supply of water support alder, peachleaf willow and other willow species as well as many herbs and grasses. A detailed species listing is given in Appendix B. The riparian ecosystem is valuable for stabilizing the soil along banks, shading water surfaces, providing scenic and aesthetic values, maintaining water quality and providing aquatic wildlife habitat. Alteration of stream flows, drainage areas and riparian vegetation may lead to impaired water quality, soil erosion and reduction of aquatic wildlife habitat.

Wildlife. The riparian habitat generally provides an interface between water and land ecosystems. This "edge" effect is important not only for its diversity but also for its value as a food-producing system. Insect populations within the Fraser River and tributaries are predominantly mayfly nymphs and caddisfly larvae, with diptera larvae in the slow-water areas (Reference 32). Stream fishery studies indicate brook trout as the predominant fish species, with limited catches of rainbow trout and cutthroat trout (Reference 33). The Willow Creek Reservoir and Granby Reservoir are artificially stocked. Game fish include rainbow trout, lake trout, brown trout and some kokane salmon. Rough fish probably include western white sucker, longnose sucker, northern creek chub, longnose dace, northern fathead minnow and central johnny darter (References 34 and 35).

Mammals living within the riparian habitat are the muskrat and the beaver, which constructs numerous dams along watercourses. Other mammals favoring the riparian zone include the deer mouse, meadow vole, mink and raccoon (Reference 36).

The riparian-aquatic habitat harbors the widest diversity of bird species. Predominant species include the yellow warbler, yellow-rumped warbler, yellow-headed blackbird, red-winged blackbird and six species of swallow. Within pond and reservoir areas, mallard, green-winged teal, shoveler and bufflehead duck, American coot and killdeer are found seasonally (Reference 37).

Aspen Unit--

Vegetation. Small stands of aspen are found throughout the study area, generally growing on moist slopes and ridges. Like lodgepole pine, aspen is a shallow-rooted, shade-intolerant, pioneer species which comes in quickly following a wildfire. Around Granby, Aspen units intergrade readily with Lodgepole Pine and Sagebrush units, depending on soil and moisture conditions. The aspen ecosystem has a high visual and aesthetic value and is sometimes an indicator of unstable soils.

The aspen understory is more diverse than that of the Lodgepole Pine units and supports many shrub and herbaceous species such as buffalo-berry, bitterbrush, common juniper, Oregon grape, huckleberry, currant, lupine, larkspur, Colorado blue columbine, monkshood and peavine. Grasses include mountain bromegrass, slender wheat grass, nodding brome, Thurber's fescue and squirrel tail. Other tree species such as lodgepole pine, Douglas-fir, subalpine fir and Englemann spruce are found throughout Aspen units.

Wildlife. Aspen stands constitute the major deciduous forest habitat within the planning area. Common small mammals include the deer mouse, Colorado chipmunk, long-tailed weasel and striped skunk. Elk and mule deer are found throughout the broadleaf forest. Elk herds, in particular, prefer the aspen habitat.

Bird species frequenting the deciduous forest are the black-capped chickadee, black-billed magpie, common crow and occasionally the sage grouse. Common summer residents include the mourning dove, downy woodpecker, violet-green swallow, rock wren and yellow-rumped warbler.

## Rare and Endangered Species

Within the Granby study area, the rarely occurring American peregrine falcon and gray wolf have been identified as endangered species by the Colorado and Federal legislatures (References 38 and 39). No endangered plant species were found in the study area (Reference 40).

### Peregrine Falcon--

Colorado has two recognized subspecies of the peregrine falcon: a winter nesting resident, the American peregrine (*Falco peregrinus anatum*), and the artic peregrine (*Falco p. tundrius*), a migratory visitor during the spring and fall (Reference 41). The resident subspecies is of greater concern within the Rocky Mountain area. Human activities such as road-building, forest and sagebrush clearing, game-hunting and outdoor recreation have deteriorated the quality of the environment for this species. The peregrine falcon requires high cliffs for nesting sites and a food supply of small birds. Accurate information about breeding pairs has been difficult to obtain. However, the Granby area may still have some value as a feeding range for this species.

### Gray Wolf--

The wolf historically ranged throughout Colorado and had two local subspecies: the now extinct Great Plains wolf (*Canis lupus nubilus*) and the gray wolf or southern Rocky Mountain wolf (*Canis l. youngii*), which frequents the Rocky Mountain region of Colorado, Utah, New Mexico and lower Wyoming (References 42 and 43). Wolf populations were nearly extirpated prior to 1900 by professional wolf-hunters and through poisoning, shooting, trapping and den-hunting. Within the Middle Park area there has been only one authenticated sighting of a gray wolf in the past five years (Reference 44).

The Colorado Division of Wildlife has recognized that sport hunting, trapping and predator control are not necessarily the current limiting factors for endangered species. A case in point is Rocky Mountain National Park, north of the study area. Hunting has been prohibited since 1915 in this park, which provides many natural habitat areas. Despite these factors, endangered wildlife numbers have not increased appreciably; the park is not large enough, human competition is too great and suitable habitat is not always available (Reference 49). Changes in land use, decrease in natural habitat and human disturbance appear to be the main factors leading to the endangerment of a species.

### Sensitive Ecological Areas

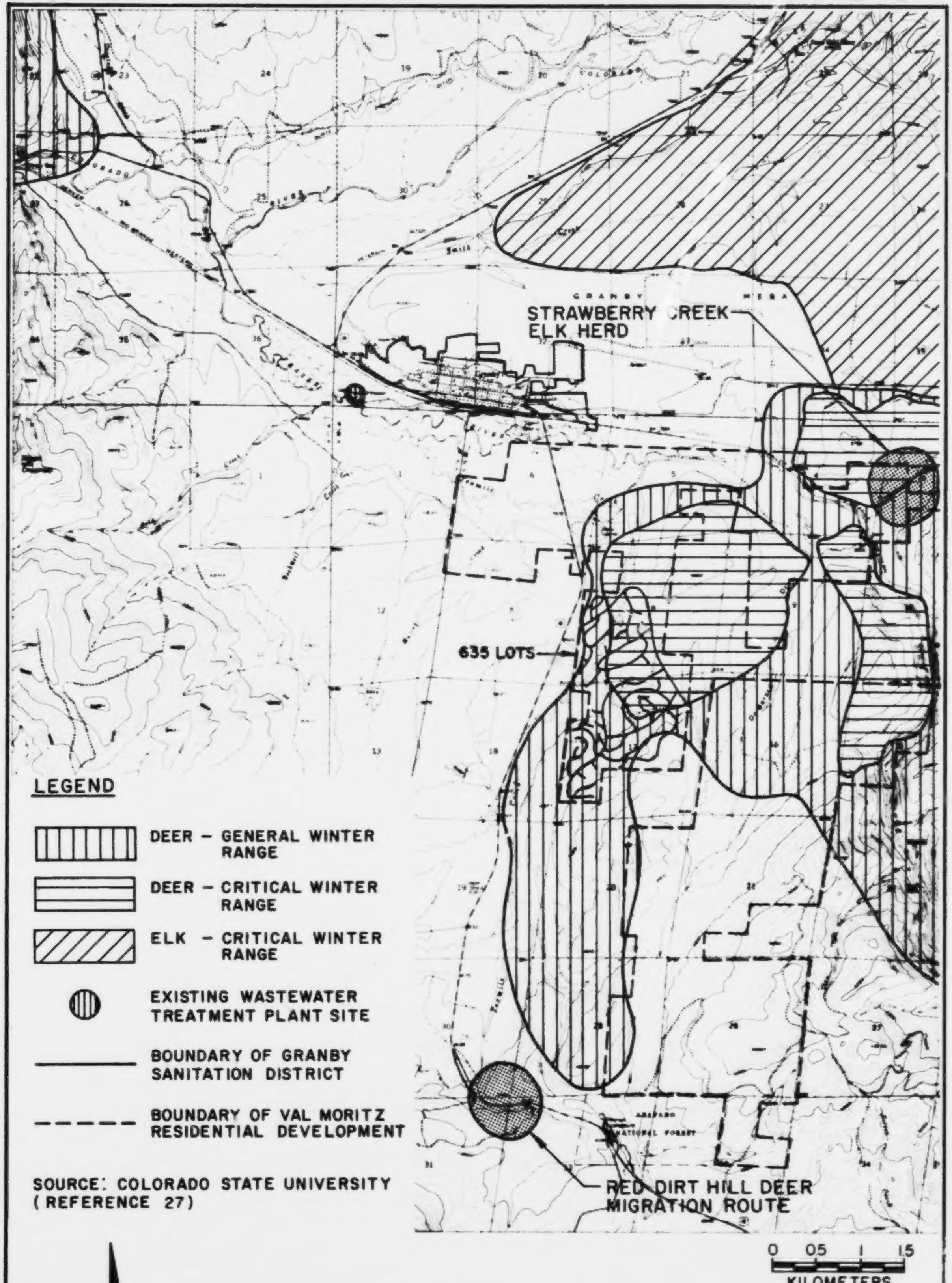
The discussion of vegetation and wildlife should be within the framework of a larger ecological context than the confines of the planning area. The relationship between these natural resources is important to environmental stability and productivity. While human interests are mainly in big game and sport-fishing species, predators, small mammals and birds are also important to the ecological balance.

With the passage of the Colorado Land-Use Act (Reference 45), resource inventories of significant vegetation and wildlife have become mandatory considerations for future land-use planning. Within the Granby study area, a majority of the bird species are spring and summer residents that migrate down to the plains or southward for the winter. The dominant resident species active during winter are mule deer and elk.

Cover, food supply and the harshness of the winter environment determine the natural carrying capacity of the area for wildlife. Wildlife survival becomes dependent upon three factors: general winter range, critical winter ranges and accessible migration routes. General winter range is defined as lower elevation areas used for feeding and cover in the winter months. Critical winter range is that area essential to survival in the event of extreme winter conditions such as heavy snowfalls. Migration routes are the various passages between high country summer ranges and lower elevation winter ranges.

Recently, wildlife ranges in East Grand County were mapped in a Colorado State University study (Reference 13). Probable deer and elk winter ranges mapped in that study are shown in Figure 12. These areas have comparatively less snow accumulation than do adjacent areas due to wind patterns and a warmer southern exposure. These factors, coupled with available food, water and cover, define favorable winter areas. Sloping sagebrush areas bordering woodlands are particularly

FIGURE 12


STRAWBERRY CREEK ELK HERD
GRANBY MESA
635 LOTS
RED DIRT HILL DEER MIGRATION ROUTE
ARAPAHO NATIONAL FOREST
LEGEND
DEER - GENERAL WINTER RANGE
DEER - CRITICAL WINTER RANGE
ELK - CRITICAL WINTER RANGE
EXISTING WASTEWATER TREATMENT PLANT SITE
BOUNDARY OF GRANBY SANITATION DISTRICT
BOUNDARY OF VAL MORITZ RESIDENTIAL DEVELOPMENT
0 0.5 1 1.5
KILOMETERS
0 0.5 1
MILES

SOURCE: COLORADO STATE UNIVERSITY (REFERENCE 27)

SENSITIVE WILDLIFE AREAS

important winter ranges. Exposed stands of bitterbrush, chokecherry, buckbrush and currant are also important for winter browse species (Reference 46).

Deer--

Within the Granby area, the sagebrush and woodland areas east of Highway 40 are general winter range for deer. Estimates of deer population within the Middle Park valley reach as high as 10,000 head, with a possible 200 to 300 deer utilizing the Granby area during the winter (Reference 44). Critical deer areas are the semi-open slopes between Tenmile Creek, the Fraser River and Strawberry Creek. Deer usually follow definite migration routes. Within the Granby area, the Red Dirt Hill deer migration pass, 7.2 km [4.5 miles] beyond Tabernash on Highway 40, has been identified. Other migration routes exist beyond the boundaries of the Granby quadrangle.

Elk--

Elk general winter range is fairly broad. Because of its size and free-ranging nature, the elk traverses deep snowdrifts impassable to deer. For this reason, both winter range and historical migration routes within the Granby area are difficult to define. However, a critical elk winter range has been identified, on the upper Granby Mesa northwest of the town of Granby. A small herd (60 to 80) known locally as the Strawberry Hill elk herd has been observed during successive winters near the junction of Strawberry Creek and the Fraser River. The elk population within Middle Park valley has been estimated at 5,000 to 6,000 (Reference 44).

Sage Grouse--

Historically, sage grouse were found in the sagebrush and grassland areas of the Granby Mesa. Sage grouse numbers have declined greatly due to habitat disturbance. At the present time, information is insufficient to determine critical areas for this species within the study area.

## Proposed Treatment Plant Sites

Five sites in the Granby area have been identified as possible treatment plant sites. Four of the sites are adjacent to the Fraser River, immediately west of town. They are located within a riparian zone and can be characterized as having pasture, marshland and sagebrush components. The fifth site is near Coyote Creek, which flows south into the Colorado River west of Granby.

A summary of the characteristics of the sites is given in Table 10; site locations are presented on Figure 10. The four riverside

Table 10. PROPOSED TREATMENT PLANT SITE ENVIRONMENTS

| Site no.[b] | Location and description | Biotic communities[a] percentage composition 1 | 2 | 3 | 4 | 5 | Comments |
|---|---|---|---|---|---|---|---|
| 1 | 1,700 m [5,500 ft] NW of existing plant, between railroad track and Fraser River. Relatively flat and screened by shrubs. | | | | 100 | | Sectioned off riverbottom, some grazing in grass areas, seasonal standing water |
| 2 | 600 m [2,000 ft] west of existing plant, on opposite bank of Fraser River. Open and flat area bounded by shrubs, 12 m [40 ft] higher than existing plant elevation. | | | | 100 | | Riverbottom area with some seasonal standing water, some grazing in flat grassy areas |
| 3 | Adjacent to existing plant on west side. Flat with shrubs facing RR track, open to Fraser River. | 30 | | | 70 | | Riverbottom leading up to sandy bank near RR track, seasonal standing water |
| 4 | 370 m [1,200 ft] NW of existing plant between RR track and Fraser River. Flat with shrubs facing RR track, open to Fraser River. | 30 | | | 70 | | Riverbottom leading up to sandy bank near RR track, seasonal standing water, limited grazing in grassy areas |
| 5 | 2.3 km [1.4 miles] NW of existing plant. Lower Coyote Creek 760 m [2,500 ft] above confluence with Colorado River. Sloping site 45 45 m [150 ft] above level of existing plant. | 100 | | | | | Open area used extensively for grazing in the past |

[a] Key to biotic communities: 1 - Sagebrush; 2 - Lodgepole pine; 3 - Grassland agriculture; 4 - Riparian and aquatic; 5 - Aspen

[b] Site numbers refer to Figure 10.

sites are similar in most respects, varying mainly in their distance from the existing treatment plant and in visibility from the road. Site 3 is closest to the existing plant and would require the least amount of pipeline construction to connect to the existing plant. Site 5 is the most remote from the present plant and would require a conveyance line, probably along Highway 40 and Highway 125, to the site. The pipeline would probably lie within the highway right-of-way.

## Proposed Agricultural Irrigation Sites

Two agricultural areas were studied in detail as potential sites for a crop irrigation alternative. The sites and the probable pipeline routes from Granby to the sites are shown on Figure 10.

### Site 1--

Site 1 is located northwest of Granby along Highway 34 and the Colorado River. The vegetation is primarily Grassland-Agriculture, with some smaller Sagebrush, Lodgepole-Pine and Riparian units occurring also. The elevation of the site ranges from approximately 6 to 50 m [20 to 160 ft] above the level of the existing sewage treatment plant. A pipeline for conveying the wastewater to the site would be approximately 3,000 m [10,000 ft] long, running parallel to Highway 34, 600 to 900 m [2,000 to 3,000 ft] to the east. An east-west lateral at the end of the main line would convey the waters within the site. Adjacent land use is rangeland and irrigated cropland. Highway 34 runs through the middle of the site. Smith Creek and two major irrigation ditches run through the site, while the Colorado River flows along the western boundary of the site. The approximate size of the land area to be irrigated with wastewater is 500 hectares [1,300 acres]. From 24 to 32 hectares [60 to 80 acres] of land would be needed for wastewater stabilization ponds. These figures pertain to use of the entire wastewater effluent stream under ultimate design flow conditions.

The environmental characteristics of the site in terms of climate, temperature and precipitation are similar to those conditions throughout the Granby area. Evaporative stress is particularly high on this site because of the winds that blow from the west through Windy Gap. Erosion potential is not high for this site. The topography is relatively level, with some steep slopes within a lodgepole pine stand along the eastern boundary. Downslope areas are irrigated cropland.

Wildlife within the site is typical of Grassland-Agriculture areas, with many small rodents and seed-eating birds. The small stands of lodgepole pine within the open areas make this an ideal feeding habitat for raptors such as the red-tailed hawk. These predatory birds need large open areas to search for prey and nearby perches for nesting.

Site 2--

Site 2 is located on the Granby Mesa approximately 3 km [2 miles] northeast of Granby and east of Highway 34. The vegetation is primarily Grassland-Agriculture, with some sagebrush on the northern periphery. The area is presently being used for livestock grazing. The elevation of the site is approximately 90 m [300 ft] higher than that of the sewage treatment plant. The probable pipeline corridor would be similar to that for Site 1. The pipeline would be slightly shorter (2,400 m [8,000 ft]), with an east-west lateral running westward to the Granby Mesa area. The environmental setting of the pipeline is similar to that of the site itself.

Adjacent land use includes irrigated cropland, rangeland and the Granby airport. Smith Creek and a tributary of Smith Creek flow through the site. The approximate eventual size of the land area to be treated is 500 hectares [1,300 acres]. From 24 to 32 hectares [60 to 80 acres] of land would be needed for wastewater stabilization ponds under the full design flow.

Erosion potential and flood potential are low. Winds blowing from the west through Windy Gap can cause high evaporative stress. The topography is relatively level. Downslope areas are rangeland and irrigated cropland.

The Granby Mesa area of Site 2 supports wildlife similar to that of Site 1 for the Grassland-Agriculture community. The upper elevations of the Granby Mesa have been identified as critical elk wintering range (Reference 44). The irrigation site and conveyance facilities would possibly encroach upon the margins of this elk habitat.

A very important difference between Site 1 and Site 2 is the superiority of soil conditions on Site 2 for land application of effluent. Furthermore, Site 2 is farther removed from the river and has a greater distance to the groundwater table, affording more filtering and adsorption action to the percolating effluent.

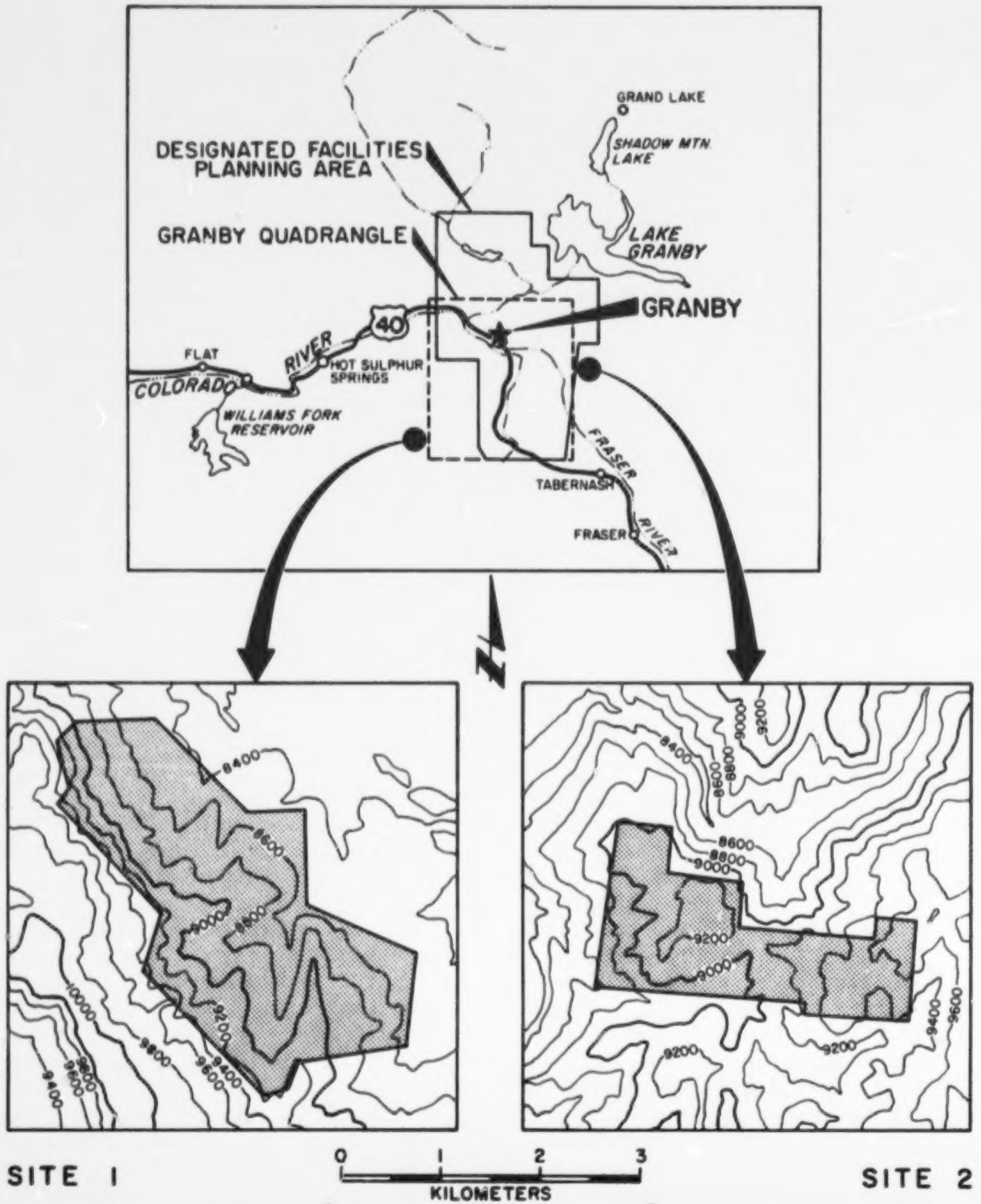
## Proposed Land Disposal Sites

Two forest areas were studied in detail as potential irrigation sites for a land disposal alternative. The connecting pipeline routes from Granby to the site are also identified. The pipeline routes are shown on Figure 10, and the sites on Figure 13.

Site 1--

Site 1 is located in the Arapaho National Forest, approximately 10 km [6 miles] south of the present sewage treatment plant. The position of the U.S. Forest Service toward land application is generally one of

FIGURE 13


GRAND LAKE
SHADOW MTN. LAKE
DESIGNATED FACILITIES PLANNING AREA
GRANBY QUADRANGLE
LAKE GRANBY
GRANBY
40
FLAT
RIVER
HOT SULPHUR SPRINGS
COLORADO
WILLIAMS FORK RESERVOIR
FRASER
RIVER
TABERNASH
FRASER
8400
8600
8800
9000
9200
9400
9600
9800
10000
SITE 1
SITE 2
0
1
2
3
KILOMETERS
0
1
2
MILES

POTENTIAL SITES FOR LAND DISPOSAL OF EFFLUENTS cautious optimism. Wastewaters acceptable for land application on National Forest land include those that have received primary treatment and secondary treatment, with chlorinated lagoon wastewater being considered equivalent to secondary treatment (Reference 51).

The vegetation consists of stands of lodgepole pine mixed with smaller Aspen units. The site is approximately 210 m [700 ft] higher in elevation than the sewage treatment plant. The pipeline route to the site would cross the Fraser River near the existing treatment plant and would extend 6 km [3.8 miles] southward and 3 km [2 miles] westward to the actual site. The pipeline corridor would transect Riparian, Grassland-Agriculture and Sagebrush vegetation units. This corridor would involve crossing several watercourses, including the Fraser River, Rockwell Creek, Muller Creek and Eightmile Creek, as well as approximately six roads. Adjacent land use is primarily National Forest, with some rangeland to the north. A fork of Eightmile Creek runs through the site. The approximate size of the land area to be treated is 8 sq km [3 sq miles]. From 24 to 32 hectares [60 to 80 acres] of land would be needed for wastewater stabilization ponds.

The environmental characteristics of the site in terms of climate, temperature, precipitation and evaporation are similar to those conditions throughout the Granby area. Erosion potential, flood potential and wind velocity are low because of the location of the site within a Lodgepole Pine forest unit. The topography is mostly gently sloping, facing north, with the hillsides having approximately a 10 percent slope. Downslope areas are primarily Sagebrush and Grassland-Agriculture units being used as rangeland. The removal of some trees would be necessary for access to the forest site. Wildlife occurring within this site would be typical of the Lodgepole Pine unit, with some variants from the Aspen community.

### Site 2--

Site 2 is located on Bureau of Land Management (BLM) land east of the proposed Val Moritz development area, approximately 10 km [6 miles] southeast of the sewage treatment plant. The vegetation is mainly lodgepole pine forest containing some spruce and fir, with smaller Aspen units occurring throughout. The site is approximately 400 m [1,300 ft] higher in elevation than the sewage treatment plant. The pipeline route probably would be adjacent to the Denver and Rio Grande Western Railroad right-of-way. Pipeline construction may require some grading at the approach to Strawberry Creek. The corridor would be within a riparian zone until approximately 1,220 m [4,000 ft] beyond Strawberry Creek. At that point, the pipeline would go uphill through the Lodgepole Pine community toward the irrigation site. The pipeline would cross one watercourse, at Strawberry Creek, and several accessory roads. Adjacent land use is primarily BLM land. Behler Creek runs along the southern boundary of the site; Strawberry Creek runs to the north of the site; and the Fraser River is approximately .8 km [.5 mile] to the west of the site. Runoff from the site could enter these three watercourses. The same area of land is needed as in Site 1 for land disposal and for storage lagoons under full operation.

The environmental characteristics of the site in terms of climate, temperature, precipitation and evaporation are similar to those conditions throughout the Granby area. Erosion potential, flood potential and wind velocity are not high because of the location of the site within a Lodgepole Pine forest unit. The topography in general is gently sloping, with some steep slopes on the western side up to 20 percent. Most of the site, however, has a slope from 0 to 10 percent. Downslope areas are Lodgepole Pine units abutting the watercourses mentioned above. The removal of some trees would be necessary for access to the forest site.

The potential irrigation area borders a critical elk winter range to the north and a general and critical deer range on the west. The south-facing slopes of the site are particularly important as feeding areas for wildlife in the wintertime.

## NOISE

The planning area is mainly rural in nature, with very few stationary noise sources. Traffic along U.S. Highway 40, aircraft activity in the vicinity of Granby Airport, and the Denver and Rio Grande Western Railroad comprise the main sources of noise. Occasionally, temporary construction activities contribute to the local noise level. Of these, automobile noise is the most continuous element.

U.S. Highway 40, which passes through Granby, carries approximately 4,250 cars per day during the peak summer periods. Typical noise levels of mixed traffic at 80 km/hr [50 mph] (measured 15 m [50 ft] away) on a low- to medium-density highway range from 60 to 75 decibels (Reference 47). Automobile traffic speeds within Granby are regulated by reduced speed limits. Thus the ambient noise level within the city limits compares to a moderately busy street with noise ranges from 50 to 75 decibels at close distances. These background noises are generally within tolerable limits and are confined mainly to populated areas and roadways. They decrease sharply within short distances and generally do not affect the overall peaceful nature of this mountain area.

## ODOR

The existing Granby wastewater treatment plant emits odors during occasional periods of hydraulic overloading and/or adverse climatic conditions. On three separate visits during the summer and fall of 1975, odors were detected up to 100 m [300 ft] downwind of the treatment plant; however, at distances greater than 100 m from the plant, odors were generally undetectable. There are no other major sources of odor in the planning area except for the solid waste disposal landfills, which are removed from places of human habitation.

## VISUAL AND AESTHETIC ENVIRONMENT

The planning area is located in a very scenic part of the Rocky Mountains. U.S. Highway 40 climbs over the rugged Front Range and enters the upper Fraser River Valley at Berthoud Pass. Following the Fraser River, the road descends through evergreen forests, past the Winter Park Ski Area, and then levels out on the floor of the large mountain valley known as Middle Park. The valley floor is characterized by irrigated hay meadows bordered by forest.

Following the highway on to Granby, it is obvious that this natural beauty is attracting accelerating usage by people. The Winter Park Ski Area has only recently expanded to nearly twice its former size; condominiums, restaurants and motels line the road at several places, billboards announce that land and vacation housing is for sale. On the south edge of the town of Granby, the administrative offices of the large proposed Val Moritz development are situated at the entrance of a recently completed road system which leads onto previously undeveloped land.

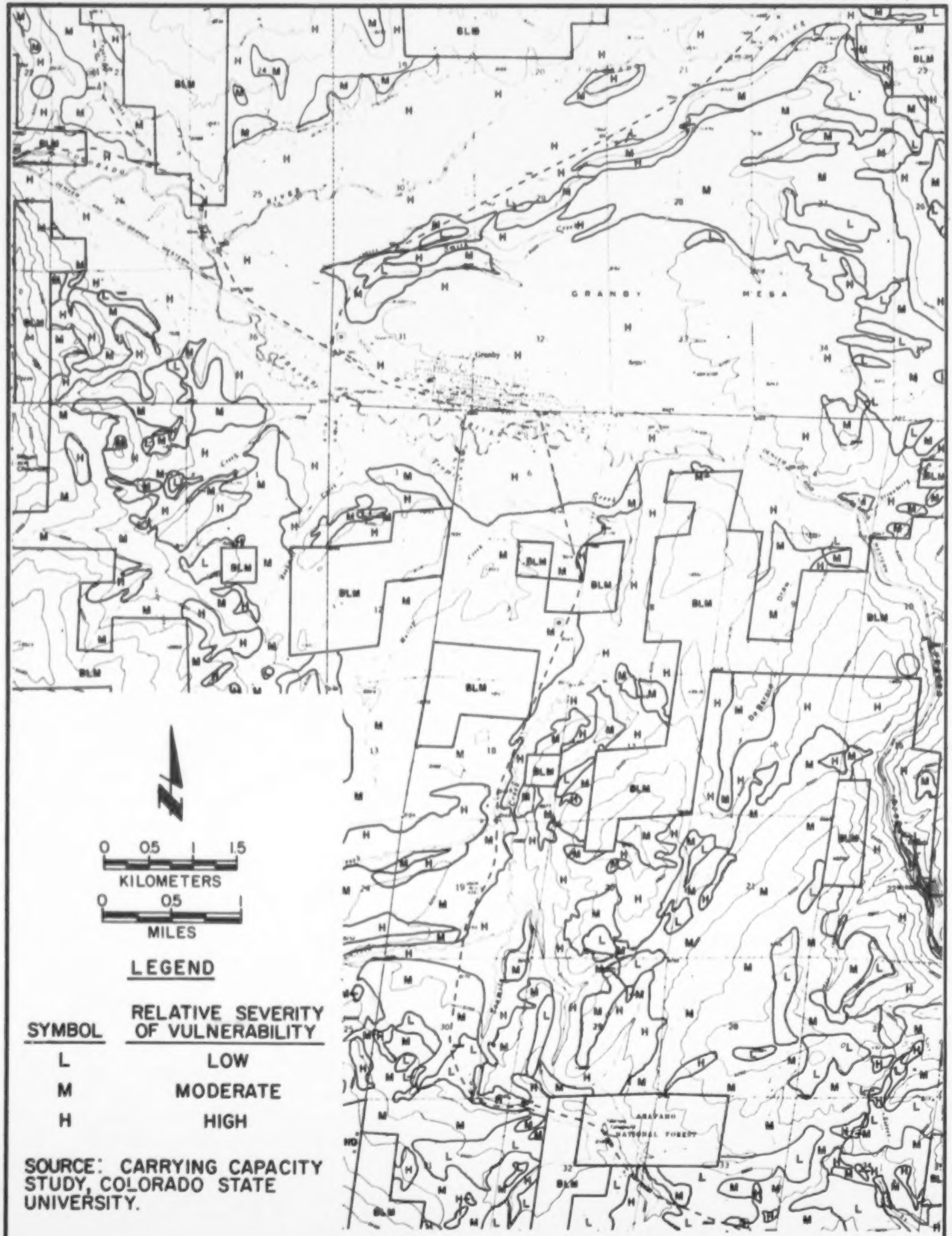
The present openness of the Granby area allows unobstructed views of the natural landscape. The mosaic of vegetation determines to a degree the "naturalness" of the landscape. Many people associate naturalness with high visual quality. Where a natural feature of the landscape has been replaced or altered by human activity, visual quality generally decreases. Areas above the plane of vision, such as hillsides and mountain passes, are more susceptible to this effect. The visual vulnerability of various parts of the Granby area is shown in Figure 14. Examples of high visual vulnerability are the recent roadcuts and resultant slope failures that have scarred some of the hillsides in the southeastern part of the planning area. The existing sewage treatment plant, on the other hand, has lower visual vulnerability because it rests below the highway grade. The visual effects of this structure are further mitigated by the screen of vegetation.

## AIR QUALITY

The Granby planning area falls within the Yampa Air Quality Control Region (AQCR), defined by the Colorado State Air Pollution Control Commission (Reference 48).

Pollution control priorities are assigned according to existing air quality data, population factors and trends, degree and type of industrialization, amount of vehicular traffic and topographic and mete-

FIGURE 14


GRANBY MESA
Granby
BLM
ARAPAHO NATIONAL FOREST
0 0.5 1 1.5
KILOMETERS
0 0.5 1
MILES
LEGEND
SYMBOL
RELATIVE SEVERITY OF VULNERABILITY
L LOW
M MODERATE
H HIGH
SOURCE: CARRYING CAPACITY STUDY, COLORADO STATE UNIVERSITY.

VISUAL VULNERABILITY OF SITES IN THE GRANBY AREA orological factors. Pollution priorities for the regions determine the amount and type of air pollution control program emphasis to be applied. The Yampa AQCR has the lowest population in the state. The limited agricultural and industrial activities in the region produce only a minor air pollution burden. Therefore, this region, which includes five northwestern counties, is classified as a Priority III retion (where III is lowest on a scale of priorityies from I to III) for all air pollutants:

AQCR Priority Classifications

| AQCR | Particulate | $SO_2$ | CO | $NO_x$ | HC-$O_x$ |
|---|---|---|---|---|---|
| Yampa | III | III | III | III | III |

The regional summary of all major air pollutants for the Yampa AQCR is quoted from the State Air Pollution Report (Reference 48) and shown in Table 11.

Table 11. ANNUAL POLLUTANT LOADS IN YAMPA AIR QUALITY CONTROL REGION[a]

| Pollutant | Total annual emmissions in Yampa AQCR<br>metric tons | <br>short tons |
|---|---|---|
| Particulates | 2,667 | 2,940 |
| Sulfur dioxide | 6,594 | 7,269 |
| Carbon monoxide | 41,836 | 46,115 |
| Nitrogen oxides | 6,390 | 7,044 |
| Hydrocarbons | 3,558 | 3,922 |
| Total | 61,054 | 67,290 |

[a] Includes Grand, Jackson, Routt, Moffat and Rio Blanco counties.

Source: Colorado State Air Pollution Control Commission (Reference 48).

At present there are three stationary sources of air pollution in the Granby area: (1) a wigwam-type waste burner serving a sawmill and emitting carbon monoxide; (2) an asphalt batch plant with controlled emission (which, without controls, would emit about 91 tons [100 short tons] per year of particulates into the air); and (3) a cement batch plant which has recently come into compliance with air pollution control requirements (Reference 49). Emission data for these sources and for three nearby sources are presented in Table 12. The nearest particulate monitoring station is located in Kremmling, where the annual geometric mean particulate concentration was 53 µg/cu m last year (allowable limit 45 µg/cu m). However, it is difficult to extrapolate this information to Granby, where different topographic and meteorologic conditions prevail.

In general, air quality in Granby is fair to excellent, with clean, fresh air, unimpaired visibility and clear, deep-blue skies during most of the year. The high elevation and great incidence of sunlight (and ultraviolet radiation) make ozone a special air pollutant of particular concern in the area, especially with regard to sources such as wastewater treatment plants (Reference 50). Carbon monoxide is another pollutant of concern in this region due to the rather high background emissions of the present sources.

## RELATED PROGRAMS IN THE PLANNING AREA

### The Windy Gap Project

The Northern Colorado Water Conservancy District has long planned a water diversion project including a dam at Windy Gap and pumpage of water to Willow Creek Reservoir and the Three Lakes System. Ninety percent of the water from the Three Lakes System (60 to 67 million cu m [48,000 to 54,000 ac ft]) would be released for use by communities on the eastern side of the Rockies (References 13 and 52). Pumping of water from this reservoir would be conducted only during 100 days of the high-runoff period per year. In addition to providing water for the eastern slopes, the project would assure adequate winter water supplies for future development in the Middle Park communities.

The Windy Gap project is now ready for final engineering design; an environmental impact assessment is being prepared by the U.S. Bureau of Reclamation, and engineering optimization studies are being concluded by a consultant. A conditional decree permitting the implementation of the project has been issued by the courts and is being challenged by affected water rights appropriators. Eventually, the Colorado Supreme Court may issue a final decree approving or rejecting the conditional decree. It is estimated that 1978 is the earliest that construction can begin, with possible delays to 1980 or 1981.

A potential impact of the Windy Gap project on the Granby wastewter treatment works is the concern about eutrophication in the Three Lakes System. The Windy Gap project would permit introduction of additional nutrients and other elements potentially detrimental to water quality into the Three Lakes System. Although no numerical data are presently available to indicate what parameters may be critical to maintaining high quality waters in the Three Lakes System as a result of the Windy Gap diversion, the possibility of a future requirement for additional nutrient removal from waste discharges into the Fraser River exists.

## SOCIO-ECONOMIC ENVIRONMENT

Social, cultural and economic conditions as well as existing public services are briefly described, to set the stage for evaluation of the need for expanded sewerage service and the ability of the people of Granby to afford the local share of its cost. Assessment of socio-economic impacts is based on this basic information.

## History

An area which includes the present Grand County was originally utilized as a hunting ground by various Indian tribes such as the Utes, Arapahoes, Sioux, Crows and Blackfeet. By 1860, however, fur trappers and traders, led by two English noblemen, Sir George Gore and Lord Dunraven, and two Americans, Major Jack D. Freeman and Jim Bridger, had slaughtered much of the game, and thereby forced many of the Indians to migrate westward in search of more plentiful game (Reference 53).

Settlers, mainly of English, Swiss, Scottish and German origins, established residences in the county between 1860 and 1900. Most of them were merchants and were relatively well educated. Grand County had a reported population of 413 in 1880 and 741 in 1900 (Reference 53).

The first major population boom in Grand County occurred between 1890 and 1920, during which time the population nearly quadrupled to 2,660. The economy during this period was based primarily on mining operations, railroad construction and ranching.

The population fluctuated during the first half of the century, declining by 20 percent between 1920 and 1930 to 2,130, and then, in the 20-year span from 1930 to 1950, almost doubling to nearly 4,000. Another population decline was experienced in the 1950's, with a loss of 400 residents in Grand County, reflecting the continuing national rural-to-urban population movement. Total population in Colorado during this period was on the rise.

## Archaeology

The first human visitors to Grand County may have arrived during the Pleistocene Period, though the post-Pleistocene (4000 B.C. to 2000 B.C.) is more likely (Reference 53). No serious archaeological survey has ever been undertaken in Grand County, however, though several limited surveys have been carried out (Reference 54). Indian tribes exploiting the region as a hunting ground moved "freely about with the seasons" rather than establishing permanent settlements (Reference 53). Temporary settlements leave comparatively fewer traces, which probably explains why no major archaeological sites have been found in the studies which have been made.

A survey in the summer of 1948 of the bed of "soon to be flooded Lake Granby" revealed bones, implements and pottery from the period 900 A.D. to 1300 A.D. These may have been from pre-Columbian hunting cultures of the Great Plains. From whatever origin, "it was clear that these folk were temporary visitors" (Reference 53).

The Facilities Plan notes that "There are not known to be any significant historical or archaeological sites which would be affected by the proposed facilities," a conclusion which was based on personal communication with the Colorado State Historical Society (References 1, 55).

Despite the absence of a comprehensive survey, the climate and traditional and historical information suggest that Grand County was visited seasonally until modern times, but that no permanent settlements were established. Hence it is unlikely that there are any significant archaeological sites in the planning area.

## Land Use

Historical land uses in Grand County are summarized above. The existing land uses in and around Granby include the major uses identified in the Grand County Comprehensive Plan, dated January 1970 (Reference 56). The plan is continuously being revised and is available for inspection at County Offices.

Land use in the Granby area is shown in Table 13.

Urban land in the planning area is centered in the town of Granby and consists mainly of low density residential housing. Commercial establishments are located principally along U.S. Highway 40, which is the main thoroughfare through Granby. Agricultural areas include the Fraser and Colorado River Valleys, used for hay, pasture and range lands. Public lands within the planning area include the Willow Creek Reservoir and numerous woodlands (Reference 1).

The town of Granby recently authorized the acquisition of 9.7 hectares [24 acres] of unimproved business-zoned land on the outskirts of Granby for the purpose of attracting clean light-industrial development. This is undertaken as part of a state-wide program to decentralize industrial development throughout Colorado with particular emphasis on northwest Colorado. Although promotional efforts are now underway, no tenants have yet been formally committed to this new industrial area, nor are any projections of industrial growth on this site currently available. It should be noted, however, that even modest industrial growth in this area might have a potentially significant effect on the small existing population base in Granby. No indications, however, of such a significant impact in the foreseeable future are forthcoming from local planning officials at this time.

The Comprehensive Plan of January 1970 describes predicted growth trends as shown in Table 14.

### Val Moritz Development--

The Del Webb Corporation of Phoenix, Arizona, in a joint venture with financial backers, has undertaken development of a large recreation and second-home subdivision known as Val Moritz, comprising 1,922 hectares [4,750 acres] on the outskirts of Granby. A total of some 10,000

Table 13. EXISTING LAND USE IN GRANBY AND THE SURROUNDING AREA

| Type of use | Land developed in Granby | | Land developed in region | | Total | |
|---|---|---|---|---|---|---|
| | hectares | [acres] | hectares | [acres] | hectares | [acres] |
| One-family | 8.3 | 20.4 | 71.6 | 177.0 | 79.9 | 197.4 |
| Multiple-family | 0.2 | 0.4 | 0.4 | 1.0 | 0.6 | 1.4 |
| Mobile home | - | - | 10.3 | 25.5 | 10.3 | 25.5 |
| Motel-hotel | 1.1 | 2.8 | 6.3 | 15.6 | 7.4 | 18.4 |
| Tourist | - | - | 6.3 | 15.5 | 6.3 | 15.5 |
| Business-commercial | 6.1 | 15.1 | 6.1 | 15.0 | 12.2 | 30.1 |
| Industrial | 9.7[a] | 24.0[a] | 21.0 | 52.0 | 21.0 | 52.0 |
| Transportation-utilities | 25.2 | 62.2 | 87.0 | 215.0 | 112.2 | 277.2 |
| Public and semi-public | 1.4 | 3.6 | 23.5 | 58.0 | 24.9 | 61.6 |
| Parks and recreation | 1.5 | 3.6 | - | - | 1.5 | 3.6 |
| Total developed area | 53.5 | 132.1 | 232.8 | 574.6 | 276.3 | 682.7 |

[a] Sky-Hi News, December 12, 1975

Source: Grand County Comprehensive Plan
Sky-Hi News, December 12, 1975

## Table 14. PROBABLE NEW GROWTH IN THE GRANBY AREA

| Type of use | 1967-1980 |  |  |  | 1980-2000 |  |  |  |
|---|---|---|---|---|---|---|---|---|
|  | Town |  | Region |  | Town |  | Region |  |
|  | hectares | [acres] | hectares | [acres] | hectares | [acres] | hectares | [acres] |
| One-family | 9.3 | 23 | 60.3 | 149 | 21.9 | 54 | 94.7 | 234 |
| Multi-family | 0.8 | 2 | 3.2 | 8 | 2.4 | 6 | 4.9 | 12 |
| Tourist | 0.8 | 2 | 0.8 | 2 | 1.6 | 4 | 2.0 | 5 |
| Business and commercial | 2.0 | 5 | 0.8 | 2 | 4.0 | 10 | 1.2 | 3 |
| Industrial[a] | 13.7 | 34 | 29.9 | 74 | 15.8 | 39 | 50.2 | 124 |
| Transportation and utilities | 4.9 | 12 | 10.6 | 26 | 10.1 | 25 | 16.6 | 41 |
| Public and semi-public | 2.0 | 5 |  |  | 4.0 | 10 |  |  |
| Parks and recreation | 1.2 | 3 |  |  | 2.0 | 5 |  |  |
| Total new development | 34.7 | 86 | 105.6 | 261 | 61.8 | 153 | 169.6 | 419 |

[a] Includes recently authorized purchase of 9.7 hectares [24 acres].

Source: Grand County Comprehensive Plan

units of development are contemplated, consisting of a mixture of single-family residential lots and condominium units. Also planned at Val Moritz are recreation and commercial developments. An initial subdivision, known as Innsbruck-Val Moritz, was approved by Grand County, and sale began in 1974. The proposed development master plan for Val Moritz is schematically presented in Figure 3. In the fall of 1974, sales were halted due to financial problems. Best current information indicates that of the 635 lots, 221 have actually been sold.

No sales activity was undertaken in 1975, and no firm schedule currently exists for the resumption of sales. Local personnel at Val Moritz indicate that the sales office will reopen in the spring of 1976 (Reference 58). Other contacts with the attorney representing Val Moritz indicate that the necessary local processing of permits to reinitiate sales is not yet firmly scheduled (Reference 59).

Under the terms of the original approval given by Grand County for this subdivision, the improvements to be made at Innsbruck-Val Moritz must be completed within two years of the inauguration of sales. This two-year period expires in October 1976. County planning officials indicate, however, that the County is empowered to grant an extension (Reference). The majority of these improvements, including interceptor and collector sewer lines, as well as necessary roads and water lines, have not yet been made.

The initial development at Val Moritz has taken place under an interim agreement between Val Moritz and the Granby Sanitation District wherein, for a $10,000 cash consideration, the Granby Sanitation District agreed to accommodate wastewater treatment requirements from Val Moritz residents and to accept connections there until such time as the capacity of the existing facility was exhausted. This early agreement, explicitly temporary in nature, contemplated that a new facility would be built and that a permanent agreement with respect to the sharing of costs between Val Moritz and the Granby Sanitation District would be reached. Negotiations on a long-term agreement have been underway for some time but have not yet been concluded. The proposals of both the District and the developers specify that commitment of Val Moritz to support the operating and maintenance cost of any new facility will not be a fixed dollar or percentage commitment but will rather be based on the actual flow rate to the wastewater treatment facilities from Val Moritz (References 59 and 60). This is a particularly significant element in the consideration of potential economic impacts to the Granby Sanitation District and the population which it presently serves.

In addition to the initial 635 unimproved residential lots, Val Moritz has filed for and received preliminary plat approval of two additional condominium elements totaling 450 housing units. No formal schedule for either the construction or the sale of these units has yet been announced by Val Moritz.

### Other Potential Land Use Changes in the Area--

Granby, as the principal trading center of Grand County (Reference 56), will probably continue and expand existing commercial and residential land uses at a modest rate representing a long-term local population gain of perhaps 50 to 100 persons per year. This "endogenous" growth excludes considerations of new industrial development or the impact of Val Moritz.

Two recent developments, unrelated to the proposed project, suggest some potential increase in residential and associated commercial land uses in response to actual or potential increased employment opportunities. The Climax Molybdenum operation, 52 km [32 miles] from Granby, will employ approximately 300 people when it reaches full operation in late 1976 and will probably give rise to a total population increase of between 800 and 1,000 people distributed in various places throughout Grand County. While it is likely that some proportion of this growth will accrue to Granby, officials at the Grand County Planning Department feel that this will be a minor impact. Two communities, Hot Sulphur Springs and Kremmling, as well as certain other, smaller urban centers, occupy an interceptor position and should capture the majority of the growth effects (Reference 60).

A proposed expansion of Rocky Mountain National Park now before Congress would enlarge the Park to within 6.5 km [4 miles] of Granby and probably generate increased seasonal traffic and possibly also related administrative and support activiites, thereby expanding further residential and commercial land uses in and around Granby.

### Land Use Regulation

Responsibility for land use regulation in Grand County is shared among various agencies of the Federal, State and county governments as well as certain specially formed regional planning entities.

### Federal Controls--

At the Federal level, interaction with land use comes primarily from issuance of permits for recreational use of Federal lands. The agencies vested with this responsibility are the Bureau of Land Management and the U.S. Forest Service. In addition, the sale of lots across state lines is regulated by the Department of Housing and Urban Development.

The Federal government exerts an extensive and often effective presence in the planning area through ownership of land, leasing of timberland for logging operations, Federal highways, ski-area permits, road systems to timber and grazing lands, and other activities. All these activities have complex relationships with local economic activities, both on and off Federal lands.

### State Regulations--

In addition to statutes regulating subdivision activity, real estate development and real estate sales, two recently enacted laws are of particular interest in state land use regulation. SB 35, enacted in 1972, significantly sharpens the definition of subdivisions, bringing a wider range of development activity under subdivision regulations, and further specifies that the subdivision ordinances of various counties be strengthened and brought into conformity with state standards. Notable among the state standards in SB 35 are requirements for "performance guarantees" provided by a developer to assure that the land improvements promised by him to the buyers or required of him under the terms of the local and state regulations will be carried out. These guarantees are to be evidenced by performance bond, cash or other liquid assets deposited as guarantees, land or other suitable collateral. Under the terms of this performance guarantee, adequate wastewater treatment facilities together with required sewer interceptor and collection lines are specifically included as items to be bonded or otherwise guaranteed before the subdivision can be approved for sale.

In 1974, the Colorado State Legislature passed HB 1041, a law concerning land use which has as its charter the protection of all land within the state and the encouragement of comprehensive and systematic land use policies by local government. Under the terms of this law, the state will aid local government through financial and technical assistance to develop a basic classification and regulatory land use program. The law designates a variety of areas and activities of state interest, which include, among others, mineral resource areas, natural hazard areas, areas with significant historical or natural importance, and areas around key facilities, airports, utilities, etc. The activities of state interest specifically include site selection and construction of major new domestic water and sewage treatment systems and major extensions of existing water and sewage treatment systems. They also include site selection for solid waste disposal, airports, mass transit terminals, highways, major public utilities, new communities, water projects and nuclear energy projects.

Under the terms of HB 1041, the responsibility for administering and coordinating these local government efforts toward more systematic land use classification and planning are vested in the Colorado Land Use Commission. The Commission has responsibility for coordinating and distributing state-wide guidelines governing the designation and classification of areas and activities of state interest. Grand County, along with all other counties in Colorado, has been provided with a $25,000 initial appropriation to assist in developing a work plan describing a local program for identifying, designating and administering matters of state interest. In addition, the sum of $14,000 was allocated to Grand County in 1974 for a supplemental fund for flood plain and geological hazard area identification near the communities of Granby, Hot Sulphur Springs, Kremmling, Grand Lake, and Fraser (Reference 61).

Recent (January 1976) contacts with county planning officials indicate that no significant additional progress under HB 1041 has been made in Grand County. The designation and identification process is still underway and awaits completion of the state guidelines. These guidelines have been completed by some but not all of the responsible state agencies (Reference 60). Since the designation of local priorities in Grand County specifically includes wastewater treatment facilities (HB 1041), the language of this law governing new facilities of this type is relevant. In Section 106-7-203-(A) the law specifically indicates that sound plannning must involve a consideration of whether the growth and development induced by new wastewater treatment facilities "can be accommodated within the financial and environmental capacity to sustain such growth and development" [emphasis added] (Reference 62).

State regulations affecting land use also emanate from the Department of Health, which has state-wide responsibility for water quality management. In 1975, a water quality management plan was completed for the Colorado River Basin (Reference 2). In this plan, several sub-basin areas are designated, including the Fraser-Williams Fork sub-basin which include among others the Granby Sanitation District Planning area. The sub-basin plan provides an extended description of current water quality considerations and specifically identifies a recommended plan for the Granby area calling for a new wastewater treatment plant downstream from the existing facilities. This new facility would serve Granby, Moraine Park and proposed new developments such as Val Moritz. Under the terms of this plan the new facility would be sized at 5700 cu m/day [1.5 mgd]. This sizing is predicated on the full development to a seasonal peak population of 17,000 at Val Moritz by the year 1990 (Reference 1).

It is clear from examination of the supporting material provided in Volume 3 of the Basin Plan as well as the conclusions drawn in Volume 1, that Val Moritz, assuming full development over a period of approximately 15 years, plays a major role in the increased demand for wastewater treatment facilities of the area. In neither the Facilities Plan nor the Water Quality Management Plan, is there any more extended discussion of the source and/or credibility of the growth projections for Val Moritz. It appears that these projections were based on the best available estimates during 1974, at which time the Val Moritz subdivision seemed to be experiencing rapid initial sales. Subsequent to that time sales were halted and have not yet been resumed.

### County Land Use Plans--

The most recently completed overall plan for land use in Grand County is the Grand County Comprehensive Plan dated January 1970. Specific regulation of new development in Grand County is governed by the zoning ordinance passed on November 26, 1975. Under the county zoning ordinance, ten map districts are established including an estate district (E), a residential district (R), an accommodation district (A), a tourist district (T), a business district (B), and forestry, mobile homes and unclassified districts.

The provisions of public sewer and water services has a significant bearing on lot size and lot setbacks under the terms of this ordinance. For example, in the estate district classification, the minimum lot size for subdivided land without public sewer or water is 0.4 hectares [one acre], with either sewer or water, minimum size is reduced to 0.2 hectares [20,000 square feet], and with both public sewer and public water facilities, it is reduced to 0.1 hectare [10,000 square feet]. In the residential district classification which includes the increment of the Val Moritz development known as Innsbruck, the minimal lot size without public sewer or water is 0.3 hectares [30,000 square feet]. With both sewer and water this is reduced to 0.07 hectare [7,500 square feet]. The Innsbruck-Val Moritz lots are sized and designed with setbacks which require that they have both public sewers and water.

In addition to the conventional zoning regulations, Grand County regulations also provide that in any subdivision, the roads be dedicated for public use and built to county standards. In many instances, the county may not require that roads be turned over to the county but may instead be dedicated to homeowners associations. In any case, county requirements specify that if density is 5 units per hectare [2 units per acre] or more, an 18-m [60-ft] right-of-way blacktop road must be provided.

In order to maintain land use in conformity with planning goals, especially those related to protection of environmental quality, controls stricter than those applied in the past should be developed. Grand County government, the local unit with major land use control authority on private lands in the area, has recognized deficiencies in its land regulation activities and has stated an intent to remedy this situation through the development of a new county comprehensive plan (Reference 57).

## Land Tenure

Grand County comprises approximately 484,000 hectares [1,196,000 acres], held as shown in Table 15. Of the approximately 65 hectares [160 acres] in the town of Granby, 4 hectares [10 acres] are publicly owned. In late 1975, the town voters authorized acquisition of 9.7 hectares [24 acres] of unimproved land for light industrial development.

## Population

Several population estimates and projections for the Granby area are summarized below. (The Growth Inducing Effects section of this report contains additional estimates resulting from the present study).

According to the 1970 U.S. Census the population of Grand County was 4,107 (Reference 63). Two census districts (Kremmling and Granby) are designated, dividing Grand County into eastern and western halves. The Granby division had a 1970 population of 2,902, 70.7 percent of the total county population.

Table 15. LAND TENURE IN GRAND COUNTY (1970)

| Landowner | Area | | Percentage of total land |
|---|---|---|---|
| | hectares | acres | |
| Total area | 784,445 | 1,196.160 | 100 |
| Private ownership | 121,724 | 300,552 | 25.1 |
| Val Moritz Development Company | 2,025 | 5,000 | 0.4 |
| Non-private ownership | 362,721 | 895,608 | 74.9 |
| U. S. Forest Service | 219,285 | 541,445 | 45.3 |
| U. S. Bureau of Land Management | 65,723 | 162,280 | 13.6 |
| National Park Service | 44,292 | 109,364 | 9.1 |
| State School Board | 21,838 | 53,922 | 4.5 |
| Bureau of Reclamation | 4,658 | 11,500 | 1.0 |
| State Game, Fish, and Parks | 3,960 | 9,777 | 0.8 |
| Denver Water Board | 2,965 | 7,320 | 0.6 |

Source: County Information Service Data Book; Grand County Comprehensive Plan.

The town of Granby, which is the main center of population in the planning area, had a population of 554 or 13.3 percent of the county total. All of Grand County's population is characterized as rural, with 92.9 percent designated as "rural farm." Grand County is predominantly white (Reference 63). The median age in the Granby division is 29.9 years with 33 percent of the population under age 18 and 6.6 percent age 65 and over. Males outnumber females (50.4 percent vs 49.6 percent, respectively). There have been a number of census updates and population projections for areas of relevance to this study. Population projections have been made in the Facilities Plan (Reference 1), the Water Quality Management Plan (Reference 2), the State of Colorado Division of Planning (Reference 64), and by the town of Granby (Reference 65).

The Facilities Plan has a relatively low present estimate for the population of Granby (580 in 1974). Also, its projections tend to be liberal and posit the Val Moritz planned development occurring as originally scheduled. The slow initial progress of this development as well as its uncertain legal status make questionable the assumption that Val Moritz will develop according to its original schedule. The first segment of the Val Moritz Plan projections for Grand County, Granby Sanitation District and Val Moritz are shown in Figure 15. A breakdown of the estimated 1990 population of the planning area and service area (including the Val Moritz development) is given in Table 16.

The projections made in the Water Quality Management Plan are shown in Table 17. Of particular interest are the relatively low growth rates predicted for Granby and the representation of the winter/summer fluctuations typical of resort areas.

The projections of the State of Colorado Division of Planning for Grand County are shown in Table 18. These projections are generally higher than those of the Water Quality Management Plan. No State projections were made for population growth for the town of Granby.

The 1973 population of Granby was estimated from tax returns by the State Division of Planning to be 869 (Reference 64). The town of Granby's estimate of its 1973 population was 728. More tentative estimates of the town for its 1974 and 1975 populations are 900 and 1,200, respectively, (Reference 15). The growth rate of the town thus seems to be increasing from its historic levels (as shown in Figure 15). Projections extrapolated from these past trends such as those shown in Table 17 have already been significantly exceeded.

The 1973 population of Grand County was estimated by the State of Colorado Division of Planning as 6,042 (Reference 64). This represents an increase of almost 50 percent over the 1970 population and indicates that the state's population projections (Table 18) are proving more accurate than those of the Water Quality Management Plan (Table 17). Annual census updates are generated by Granby and the state. In early 1976, the Grand County Planning Department completed an enumeration of housing in the county. These raw data will form the basis for new population estimates to be undertaken by the planning department.

### Table 16. 1990 POPULATION FORECASTS (PEAK PERIOD) USED IN FACILITIES PLAN

| Component | Service area[a] | Planning area[a] |
|---|---|---|
| Historical trend | 700 | 970 |
| Val Moritz | 12,080 | 12,080 |
| Second home-induced | 1,700 | 1,800 |
| Tourism-induced | 850 | 900 |
| Resident | 15,330 | 15,750 |
| Overnight hotel/motel | 1,400 | 1,600 |
| Total | 16,730 | 17,350 |

[a] Service and Planning areas for the proposed project shown in Figure B.

Source: Facilities Plan

Table 17. POPULATION PROJECTIONS IN WATER QUALITY MANAGEMENT PLAN
(Granby, Val Moritz, Grand County)

| Location | 1970 | 1978 | 1993 |
|---|---|---|---|
| Town of Granby | | | |
| winter | 554 | 611 | 847 |
| summer | 6,740 | 8,211 | 11,847 |
| Town of Val Moritz | | | |
| winter | 0 | 1,000 | 20,000 |
| summer | 0 | 600 | 12,000 |
| Grand County (permanent residents) | 4,100 | 6,850 | 10,250 |

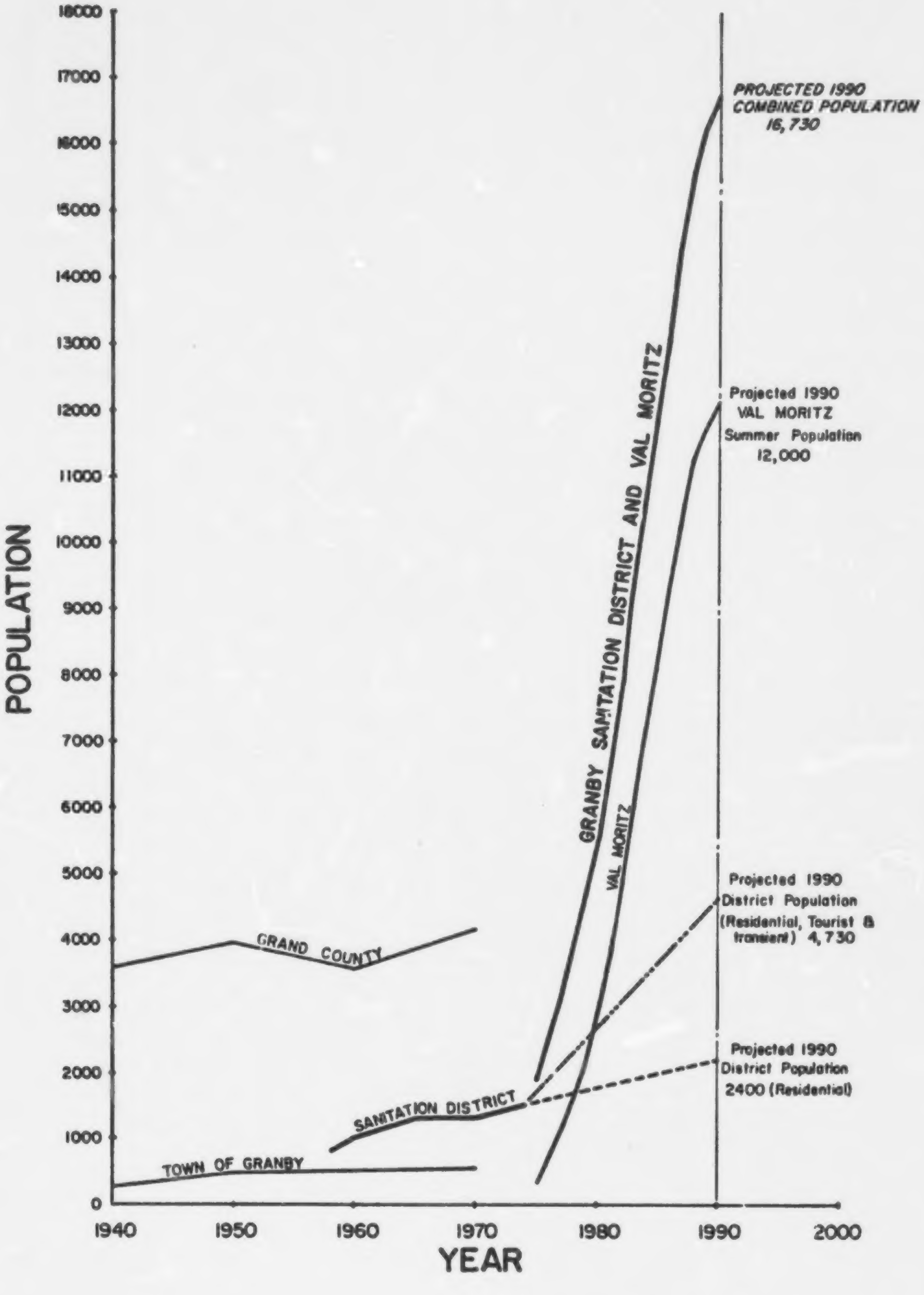
Source: Water Quality Management Plan.

Table 18. GRAND COUNTY POPULATION PROJECTIONS BY THE STATE OF COLORADO

| Projection | | | | | | | |
|---|---|---|---|---|---|---|---|
| High | 4,107 | 8,588 | 10,398 | 12,078 | 14,185 | 16,549 | 19,501 |
| Low | 4,107 | 8,541 | 10,139 | 11,300 | 12,595 | 13,793 | 15,079 |

Source: State of Colorado Division of Planning.

FIGURE 15



SOURCE: FACILITIES PLAN

## GRANBY SANITATION DISTRICT POPULATION PROJECTIONS

The growth rate in Granby and Grand County in the early 1970's has increased as a result of a number of factors. The tourist and recreational activity in the area is an important factor for Granby and the county as a whole. Elsewhere in the county, second home developments have been starting up. Examples include the condominium developments in Fraser and Winter Park. Other growth and employment affecting Granby and the county are major mine related tunneling construction and an ore processing mill now nearing completion, both by AMAX, Inc. Some of the construction workers for the tunneling project lived in Deadwood Trailer Court, a facility near Granby accommodating about 200 people. Another development just outside the Granby city limits is Moraine Park, a community of 51 houses and trailer homes. Granby and these adjacent developments will probably not receive much direct population impact from the AMAX mill being constructed near William Forks, which is about 52 km [32 mi] from Granby. Other towns are located nearer the mill site. Among these towns are Kremmling, Parshall and Hot Sulphur Springs (References 65,66, 67).

Population growth in Granby has been moderate, increasing by only 10.1 percent (from 503 to 554) during the 1960's, compared to a state increase of 24.9 percent over the same period (References 63, 56, 68). During the 1970-1973 period the town of Granby has grown at roughly the same rate as Grand County as a whole (57 percent and 47 percent increases, respectively) (Reference 65). Current projections assume immediate and rapid development of Val Moritz. In light of the delay in the sales and development of Val Moritz properties and an apparent scaling down of projections for future sales, it seems advisable to develop some alternate estimates. These projections consist of two components, an endogenous component which reflects the growth that is anticipated whether or not Val Moritz is built, and the Val Moritz induced component.

Since the state projection of Granby's growth seems to correspond reasonably well with the observed recent experience, a projection of endogenous growth based on the state population projection for the county as a whole appears to be justifiable. If Granby is to maintain its present share of county-wide population, its population will grow to slightly more than 1,400 by 1980, slightly less than 1,600 by 1985, and to approximately 1,760 by 1990. These numbers are predicated on a 14 percent share of the lower county population projection shown in Table 19.

The projection of population growth induced by the development of Val Moritz involves a wide range of assumptions. These assumptions and certain important qualifications on these projections are discussed at length under Growth Inducing Effects.

Presented in Table 19 is a summary of the endogenous growth discussed above and the projected Val Moritz induced growth as developed in the Growth Inducing Effects section. The peak population under the base Val Moritz projections would reach approximately 9,700 by 1990. Using reduced projections, that figure would only be about 7,400. Since sales have not yet resumed and usually several years elapse between lot sale and house construction, the impact of Val Moritz on total population will

Table 19. PROJECTED POPULATION GROWTH OF GRANBY AND VAL MORITZ, 1975-1990

| Val Moritz population | Town of Granby |  |  | Val Moritz[c] |  |  | Combined peak population |
|---|---|---|---|---|---|---|---|
|  | Local (no V.M.)[a] | V.M. induced[b] | Total | Cum. Sales | Cum. Hookups | Peak pop. |  |
| **Base projection** |  |  |  |  |  |  |  |
| 1975 | 1,200 | 0 | 1,200 | 0 | 0 | 0 | 1,200 |
| 1980 | 1,420 | 60 | 1,480 | 2,000 | 300 | 900 | 2,380 |
| 1985 | 1,580 | 380 | 1,900 | 4,000 | 1,200 | 3,600 | 5,560 |
| 1990 | 1,760 | 750 | 2,510 | 6,000 | 2,400 | 7,200 | 9,710 |
| **Reduced projection** |  |  |  |  |  |  |  |
| 1975 | 1,200 | 0 | 1,200 | 0 | 0 | 0 | 1,200 |
| 1980 | 1,400 | 40 | 1,460 | 1,300 | 200 | 600 | 2,060 |
| 1985 | 1,580 | 300 | 1,880 | 2,700 | 800 | 2,400 | 4,280 |
| 1990 | 1,760 | 580 | 2,340 | 4,000 | 1,600 | 4,800 | 7,140 |

[a] Assumes Granby to be 14% of county using low state projections of county population (see Table 18) to population.

[b] See Table 42.

[c] See Table 40.

[d] Assumes 1/3 reduction in cumulative sales.

be minor through 1980. Thereafter, the effect of Val Moritz will probably increase both on the induced growth to Granby and on its peak or seasonal population.

## Transportation and Circulation

The major access roads to the planning area are U.S. Highway 40; Highway 34, a State primary highway; and Highway 125, a State secondary highway. These roads are shown on Figure 5.

Highway 34 begins about 900 m [.05 mi] from the western limits of the town of Granby at the junction with Highway 40. Highway 34 leads to the Three Lakes region and Rocky Mountain National Park. Average year-round daily traffic flow between Shadow Mountain Lake and the Highways 40/34 junction is 2,550 cars per day (Reference 69).

Highway 125 leads to the junction with Highway 40 from the north, passing through Arapaho National Forest. The junction is located approximately 3.2 km [2 mi] west of the junction of Highways 40 and 14. Traffic flow on Highway 125 is a sparse 380 cars per day.

Average daily traffic flow on Highway 40 just west of Granby is 4,250 cars per day. Assuming that traffic during three summer months is heavier than winter traffic in accord with the winter/summer population differences shown in Table 17, the summer traffic flows would be about three times heavier than the annual average and the winter traffic would be roughly one-fourth as great as the annual average. The average daily traffic on Highway 40 east of Granby is 2,950. The heavier traffic to the west of Granby on Highway 40 reflects the circulation traffic between Granby and the points to the west and north (Reference 70).

The Colorado State Division of Highways indicates that these three major access roads are adequate for the existing traffic flows through the planning area (Reference 71).

Granby is served by bus, railroad, and air transportation facilities. Bus service is available from the Continental Trailway Bus Station in Granby. Buses operate along U. S. 40 twice each day, once eastbound and once westbound. Planes fly into Granby-Grand County Airport from Denver and Steamboat Springs. Rocky Mountain Airways offers two scheduled flights per day inbound and two outbound. The Denver and Rio Grand Western Railroad Company offers passenger service six times weekly. Eastbound trains stop on Tuesday, Friday, and Sunday, and westbound runs are on Monday, Thursday and Saturday. In addition, about 16 freight trains pass through Granby daily (References 70, 72 and 73).

## Recreation

Grand County, in which the planning area is located, offers a wide variety of outdoor recreational activities. Rocky Mountain National Park, to which Granby offers access, has an average annual attendance of 1.75 million visitors. Along with Arapaho National Forest, over 405,000 hectares [one million acres] are available for fishing, hiking, backpacking and camping. Pleasure driving on the scenic roads in the region can also be enjoyed. Winter activities include downhill and crosscountry skiing, sledding, ice skating and snowmobiling. In the Three Lakes region, Lake Granby, Grand Lake, and Shadow Mountain Lake are available for swimming, boating and water skiing. Lake Granby is the largest body of water above 2,440 m [8,000 ft] elevation in North America and holds 617 million cu m [500,000 acre feet] of water. There are also numerous smaller lakes which include Willow Creek Reservoir and Monarch Lake. Excellent fishing is available from the lakes and rivers (Colorado and Fraser) in Grand County (Reference 74).

Hunting and fishing are of particular importance in Grand County. According to a 1967 survey, cold water fishing and big game hunting accounted for 9.5 million and 13,000 recreation days, respectively, in a single year (Reference 75).

The Three Lakes region is the main center of water-based recreation in Grand County. The 1970 demand for various water-based recreation was shown in the Three Lakes Regional Planning Study as follows (Reference 76).

| Activity | Activity days |
|---|---|
| Boating | 36,628 |
| Swimming | 113,768 |
| Fishing | 170,024 |
| Ice skating | 2,400 |
| Ice fishing | 4,500 |

Source: Three Lakes Regional Planning Study

Tables 20, 21 and 22 show the available recreational areas by administration, type and capacity.

## Table 20. INVENTORY OF OUTDOOR RECREATION AREAS IN GRAND COUNTY, BY ADMINISTRATION

| Administration | Area | | |
|---|---|---|---|
| | hectares | acres | percent |
| Federal | 315,999 | 780,245 | 94.4 |
| State | 141,406 | 3,471 | 0.4 |
| County | 3 | 8 | 0.0 |
| City | 316 | 780 | 0.1 |
| Other local government | 597 | 1.475 | 0.2 |
| Quasi-public | 0 | 0 | 0.0 |
| School boards | 1 | 2 | 0.0 |
| Private | 16,586 | 40,954 | 5.0 |
| Totals | 334,908 | 826,935 | 100.0 |

Source: Grand County Information Service Data Book.

## Table 21. INVENTORY OF OUTDOOR RECREATION FACILITIES IN GRAND COUNTY, BY TYPE

| Facilities | Area | |
|---|---|---|
| Swimming and wading pools | 986 sq m | 10,612 sq ft |
| Swimming beaches | 1,843 sq m | 19,836 sq ft |
| Picnic areas | 114 hectares | 282 acres |
| Tent camping | 1,087 hectares | 2,686 acres |
| Trailer camping | 882 hectares | 2,179 acres |
| Ski slopes | 350 hectares | 865 acres |
| Golf courses | 144 hectares | 355 acres |
| Ice skating | 2 hectares | 6 acres |
| Playing fields | 16 hectares | 39 acres |

Source: Grand County Information Service Data Book.

Table 22. INVENTORY OF OUTDOOR RECREATION FACILITIES IN GRAND COUNTY BY CAPACITY

| Facility | Number |
|---|---|
| Hotel, motel, lodge, etc. (units) | 1,321 |
| Organized camp (beds) | 320 |
| Ski lifts (persons per hour) | 9,400 |
| Tennis courts | 2 |
| Golf course (holes) | 63 |
| Putting golf course | 3 |
| Driving range | 4 |
| Picnic areas (units) | 538 |

Source: Grand County Information Service Data Book

Within the planning area are the following recreational areas: Willow Creek State Recreational Area with 324 hectares [800 acres], Tabernash Campground, Y.M.C.A. Camp Chief Ouray with 156 hectares [385 acres]. The proposed Val Moritz development is slated to include facilities for volleyball and swimming, a golf course, equestrian center, boating area, and a winter recreation and skiing area (Reference 77).

The U.S. Forest Service and the U.S. Bureau of Land Management (BLM) must approve plans for recreational development on land under their administration. According to the BLM, there is one pending application for ski resort development, on land near Sheep's Mountain (Reference 78). The U.S. Forest Service reports a number of inventoried sites with potential for ski resorts, but there are no concrete plans for their use at this time. These sites include a possible addition to Winter Park in the Little Vasquez Creek area, a new resort in the Devil's Thumb Park area, and three sites in the Kawaneechee area, the most promising of which is Bowan Gulch (Reference 79).

The County Information Service of Colorado State University cites a recreational survey done in 1967 for the Colorado Outdoor Recreation Comprehensive Plan (Reference 75). Table 23 lists the demand, supply and surplus capacity of outdoor recreation in Grand County for 1966.

## Land and Other Property Values

The primary agricultural land uses in the area are livestock related, such as grazing or feed crop production. In order to buy land for ranching in the area, a whole ranch would probably have to be bought, a typical price being $1,235/hectare [$500/acre]. Land costs are 50 percent to 67 percent lower than they were a few years ago when speculation concerning the effect of the Val Moritz development inflated prices (Reference 81).

## Table 23. RECREATION DAYS, BY ACTIVITY (1966)
(user days)

| Activity | Demand | Supply | Surplus |
|---|---|---|---|
| Fishing - cold water | 44,609 | 9,509,000 | 9,464,391 |
| Fishing - warm water | 1,491 | 0 | -1,491 |
| Swimming | 24,062 | 9,134 | -14,928 |
| Boating | 12,392 | 64,080 | 51,688 |
| Waterfowl hunting | 669 | 62,387 | 61,718 |
| Horseback riding | 46,513 | 11,559,000 | 1,512,487 |
| Playing outdoor games | 98,879 | 93,600 | -5,279 |
| Playing golf | 1,578 | 400,000 | 398,422 |
| Playing tennis | 3,651 | 2,400 | -1,251 |
| Picnicking | 43,547 | 430,400 | 386,853 |
| Trailer camping | 1,614 | 915,180 | 913,566 |
| Tent camping | 7,870 | 1,128,120 | 1,120,250 |
| Organized group camping | 2,664 | 13,440 | 10,776 |
| Driving | 67,220 | 137,520 | 70,300 |
| Hunting - small game | 9,895 | 730 | -9,165 |
| Hunting - big game | 8,783 | 13,029 | 4,246 |
| Snow skiing | 32,454 | 7,332,000 | 7,299,546 |
| Ice skating | 15,586 | 18,000 | 2,414 |
| Boating, sailing, canoeing | 14,016 | 4,263,600 | 4,247,584 |

Source: County Information Service Data Book.

Within the town of Granby a 25 to 30 m [80 to 100 ft] frontage lot has a present market value of about $4,000-$5,000. Outside of town, residential land costs approximately $4,900-$7,400/hectare [$2,000-$3,000/acre]. In the Val Moritz development, lot sizes average .13-.20 hectares [1/3-1/2 acre] and prices range from about $12,000 to $28,000 per lot (Reference 77).

Most commercial quality timber land is found in National Forests, which cover roughly 78 percent of the county. The land is not for sale, but the National Forest Service sells the timber to the highest bidder, which then hires its own loggers (Reference 81).

Total valuation of taxable property in Grand County increased from $28,464,750 in 1973 to $32,672,400 in 1974, an increase of $4,207,650 (15 percent). The assessed valuation of property in Grand County is at 30 percent of market value (Reference 82). The 1974 "Abstract of Assessments and Levies" lists the valuation of assessed property as follows:

| | |
|---|---|
| Real estate and improvements | $ 25,821,290 |
| Personal property | 2,563,870 |
| Public utilities assessed by Department of Property Valuation | 4,287,140 |
| Total | $ 32,672,400 |

The assessed valuation of the town of Granby in 1974 was $1,722,870, that of the Granby Sanitation District was $2,058,890 (Reference 83).

All of the above figures are based on 1968 values; preliminary results of the new valuation now in progress indicate that the assessed valuation for Grand County will be $70,000,000 (Reference 84). Granby follows the general county trend quite closely, and its assessed valuation will probably more than double in the 1975 assessment (Reference 82).

## Tax Base

The town of Granby obtains tax revenues from property taxes and from a town sales tax. The annual property tax rate for Granby in 1974 was 12.00 mills (1.2¢) per $100 assessed valuation (Reference 83). The revenue obtained from this tax was $42,018 in 1974. The revenue obtained from the 2 percent city sales tax was about $90,000 in 1974 (Reference 83).

The city sales tax revenues are allocated as follows: 48 percent for streets and roads, 2 percent for parks and recreation, and 50 percent for the general fund (Reference 85).

The tax revenues for the Granby Sanitation District are obtained from a property tax and from service and connection fees. Service fees for those served by the district account for about $24,000 in revenues annually ($60/yr service fee for each of the approximately 400 connections to the system). The fee for new connections to the system raises about $8,750 annually ($250/new connection x about 35 new connections/year) (References 1, 86). In 1974, the Granby Sanitation District raised $7,947 through its 3.6 mill levy on the assessed valuation within the district (Reference 82).

The allocation of tax revenues in Grand County is shown in Table 24.

Table 24. ALLOCATION OF TAX REVENUES

| Allocation | Revenue, $ | Percent of total revenue |
|---|---|---|
| School districts | 1,436,325 | 54.6 |
| Cities and towns | 109,311 | 4.2 |
| County purposes | 708,338 | 26.9 |
| Local improvement district | 375,122 | 14.3 |
| Predatory animal fund | 123 | 0.0009 |
| County total | 2,629,219 | 100.0 |

Source: Abstract of Assessments and Levies - Grand County, Colorado.

## Labor Force

The 1970 census (Reference 63) for the Granby Division Census District indicated that close to one-third of the area's labor force was involved in wholesale and retail trade. In terms of occupation, nearly one-third of the labor force was employed as service workers. These employment figures were the highest of any trade or occupation, not unexpected in an area whose economy relies heavily on recreation and tourism. Resorts and motels, for example, provide a significant portion of jobs for service workers.

Although Grand County is a rural area, only 10.1 percent of the total employed worked in agriculture. Agriculture is difficult in this area because of the short growing season, which is, in an average year, only about 41 days long (Reference 1).

Tables 25 and 26 show employment by occupation and by industry for the Granby Division Census District (Reference 63).

Table 25. GRANBY DIVISION LABOR FORCE, BY OCCUPATION (1970)

| Employed persons | Number | % of total |
|---|---|---|
| Professional, technical and kindred | 79 | 6.6 |
| Farmers and farm managers | 4 | 0.3 |
| Managers, officials and proprietors | 207 | 17.3 |
| Clerical and kindred workers | 151 | 12.6 |
| Sales workers | 7 | 0.6 |
| Craftsmen, foremen and kindred workers | 185 | 15.5 |
| Operatives and kindred workers | 96 | 8.0 |
| Service workers, including private household | 340 | 28.5 |
| Farm laborers and farm foremen | 40 | 3.4 |
| Laborers and farm foremen | 85 | 7.1 |
| Total | 1,194 | 100.0 |

Source: General Population Characteristics, U.S. Bureau of the Census.

Table 26. GRANBY DIVISION LABOR FORCE, BY INDUSTRY (1970)

| Employed persons | Number | % of total |
|---|---|---|
| Construction | 88 | 6.8 |
| Agriculture | 43 | 3.3 |
| Durable goods | 37 | 2.9 |
| Transportation | 23 | 1.8 |
| Communications, utilities | 71 | 5.5 |
| Wholesale and retail trade | 367 | 28.3 |
| Finance, insurance, business, repair | 33 | 2.5 |
| Other professional and related services | 69 | 5.3 |
| Educational services | 34 | 2.6 |
| Public administration | 88 | 6.8 |
| Other industries | 442 | 34.1 |
| Total | 1,295 | 100.0 |

Source: General Population Characteristics, U.S. Bureau of the Census.

Climax Molybdenum Company, a division of AMAX Inc., is a mining operation which employs about 50 persons in Grand County. An ore mill scheduled to be on-line in late 1976 will employ approximately 250 workers. The mill will be near Williams Fork, about 52 km [32 mi] from Granby.

Income

Income from businesses in Grand County is derived mainly from retail trade and services. Many of the businesses are dependent upon the large volume of tourist trade which peaks during July and August. The influence of tourism on the economy can be seen in the notable gain made by lodging services, which increased more than 100 percent between 1960 and 1968. Manufacturing in Grand County is of minor importance. Mining operations in the state of Colorado as a whole have been declining over recent years, though a local increase (Climax Molybdenum) is underway.

The Department of Development and Planning of the County estimates the following commercial activity in Grand County: tourism/recreation, 50 percent (of which 60 percent is summer activity); agriculture, 40 percent; and mining, timber and other, 10 percent (Reference 57).

Table 27 shows the business activity in Grand County for the years 1960, 1964, and 1968 (Reference 56).

Almost all of the business activity in the planning area is centered in the town of Granby. Land use information for 1970 shows that approximately one-sixth of the entire town is developed for business and commercial uses. Retail sales for the first three quarters of 1972 for Granby averaged 35.9 percent of the total for Grand County.

Receipts from Granby retail sales in 1972 is shown in Table 28 (Reference 76).

The 1970 median family income for all of Grand County was $8,656. For rural nonfarm families it was $8,403, and for rural farm families it was $9,313. The mean family income was $9,688 (Reference 75).

In comparison, the 1969 national and state median family income was $9,586 and $9,552, respectively (Reference 63). Of the 1,114 families in Grand County, 9 percent had incomes which were below poverty level. In 1970, poverty level income was defined as $3,195 for farm families and $3,743 for non-farm families.

In 1970 there were 87 families (12 percent) of the total of 746 families in the Granby division district which had incomes below poverty level. Sixty-four families (9 percent) had their incomes supplemented by public assistance, of which 32 families were below poverty level. Of the 388 persons with poverty status, 364 were under the age of 65. Eighty-one families (11 percent) received more than $15,000 and 47 families (6 percent) had incomes of $50,000 or more (Reference 68).

## Table 27. BUSINESS ACTIVITY IN GRAND COUNTY
(thousands of dollars)

| Business group | 1960 | 1964 | 1968 |
|---|---|---|---|
| Apparel | 65 | 62 | 41 |
| Automotive | 2,551 | 2,944 | 3,135 |
| Food | 2,139 | 1,881 | 2,122 |
| Furniture | 199 | 87 | 79 |
| General merchandise | 1,799 | 1,932 | 2,571 |
| Lumber, building | 541 | 599 | 657 |
| Other retail | 339 | 345 | 9,169 |
| Subtotal, county retail | 7,633 | 7,850 | 9,169 |
| Lodging | 1,200 | 1,713 | 2,507 |
| Professional personal services | 19 | 9 | 5 |
| Public utility | 648 | 1,078 | 1,145 |
| Farm and garden | 0 | 0 | 4 |
| Manufacturing, trading, jobbing | 712 | 1,814 | 609 |
| Total | 10,212 | 12,464 | 13,439 |

Source: Grand County Comprehensive Plan.

## Table 28. GRANBY RETAIL SALES

(thousands of dollars)

| Type of business | 1st qtr. | 2nd qtr. | 3rd qtr. |
|---|---|---|---|
| Retail trade | | | |
| Building material | 133 | 110 | 248 |
| General merchandise | 57 | 68 | 160 |
| Food stores | 150 | 126 | 240 |
| Automotive | 634 | 648 | 1,050 |
| Apparel and accessory | 45 | 14 | 24 |
| Furniture | 18 | 10 | 21 |
| Eating and drinking | 71 | 85 | 220 |
| Miscellaneous | 222 | 197 | 307 |
| Total retail trade | 1,329 | 1,358 | 2,270 |
| Services | | | |
| Financial, insurance & real estate | 1 | 1 | 2 |
| Hotels and lodging | 41 | 11 | 43 |
| Other services | 30 | 32 | 39 |
| Total services | 72 | 44 | 84 |
| Other | | | |
| Wholesale trade | 34 | 37 | 68 |
| Agriculture | - | - | - |
| Mining | - | - | - |
| Contract construction | - | - | - |
| Manufacturing | 10 | 5 | 4 |
| Transportation, communication and public utilities | 286 | 263 | 241 |
| Government | - | - | - |
| Non-classifiable | 5 | - | 82 |
| Total other industry | 335 | 305 | 395 |
| Total all industries | 1,736 | 1,607 | 2,749 |
| Percent of County | 34.1 | 38.0 | 35.7 |

Source: Three Lake Regional Planning Study.

## Public and Social Service

Social services in Grand County are primarily provided by a county staff which includes a full-time eligibility technician, half-time caseworker and community service trainee aide, and a director who supervises the social services in Grand and Summit Counties. A community counseling center located in Granby serves all of Grand County and offers professional counseling help for a wide range of mental health problems. The Jackson/Grand Council on Aging maintains a center in Granby to provide for the elderly. Social services are also provided by fraternal groups, such as the American Legion, and by church-based organizations (Reference 87, 88).

Health care facilities in the area are the East Grand Medical Center (Granby), the Granby Clinic (Granby) and the 29-bed Kremmling Memorial Hospital, 40 km [25 mi] from Granby. The facilities in Granby provide emergency medical care, while the more extensive facility in Kremmling offers a more complete range of medical services. This hospital has recently expanded its facilities and is served by the Grand County ambulance service.

A physician resides in Granby, and a public health nurse in Granby serves the Grand County area. In general, the country residents are provided with health care and social services comparable to those of other rural recreational counties in Colorado (References 75, 88, 89).

Fire protection in the Granby area is provided by a volunteer fire department. Since there are only three or four calls per month available service meets current needs. The National Park Service supplies equipment and firefighters to patrol the national parks in the area (References 88, 90, 91).

Two police officers provide the town of Granby with law enforcement services.

The study area is located in East Grand School District No. 2. The three schools in the district are Fraser Elementary School in Fraser, and Granby Elementary School and Middle Park Junior-Senior High School in Granby. There were 903 students enrolled during the 1972-73 school year; the 1971-72 school year pupil/teacher ratio was 20.5/1, 11.3 percent better than the state average. The nearest institution of higher learning is the University of Colorado in Boulder, 159 km [99 mi] drive east of Granby (References 63, 75).

The educational facilities in the district are presently operating at or above capacity. East Grand District No. 2 proposes to construct a new high school to remedy this deficiency. A bond issue will probably be put before the electorate in 1976 (Reference 92). Val Moritz, in accordance with SB 35, has transferred title to land for schools to the East Grand School District No. 2 (Reference 57).

## Public Health

The public health inspection and enforcement services in Grand County are performed by the environmental health officer. The county also retains a doctor to consult on public health problems. The Board of Health functions are carried out by the Grand County Board of Supervisors (Reference 93).

The public health problems associated with water quality are of concern for this project and are monitored by the Colorado Department of Health, Water Quality Division (Reference 1).

The Colorado State Department of Health administers the National Pollution Discharge Elimination System (NPDES) to ensure the healthfulness of the waters for human and aquatic organisms. The Department reviews treatment plant effluent self-monitoring data to determine whether NPDES permit standards are met (Reference 119).

The Facilities Plan noted a number of aspects of the Granby treatment plant effluent which are substandard by state or federal criteria. Standards not being met included those for color, turbidity, suspended solids, biological oxygen demand, residual chlorine and ammonia nitrogen. No immediate direct hazard to human health is posed by these conditions.

In recent years, state and county public health officials have taken issue with the septic tank operation at Moraine Park, a development of 51 units--mostly mobile homes--north of Granby. On November 16, 1973, the Colorado State Department of Health issued a Cease and Desist Order requiring that Moraine Park stop its improper wastewater treatment and disposal system. Specifically, the order referred to the wastewater which was surfacing from the septic tank and leach field system (Reference 94).

As of January 1976, the Moraine Park use of the improperly operating septic tank system had not ceased (Reference 94). The manager of the development has excavated two pits to be used as treatment lagoons. To date, these lagoons remain unused. This project was carried out without the necessary permit from the health department. The Facilities Plan pointed out the following deficiencies in the lagoon treatment system (Reference 1).

1. The existing lagoon treatment facilities would require several modifications to meet the standards of the Department of Public Health.

2. Right-of-way for transmission piping between Moraine Park and the lagoons appears to be unavailable except for lengthy, expensive routes.

3. Lagoon sites are too near the town of Granby and are within expected growth patterns.

4. Proposed use of lagoon effluent for irrigation purposes would be difficult and probably in violation of water rights in the area.

5. Percolation of lagoon water could possibly constitute a hazard to users of well water located in lower areas.

The recommendation of the Moraine Park manager that the town of Granby pump its sewage up to the lagoon system was rejected by the Facilities Plan because of excessive energy requirement and cost ($25,000/yr for electrical power alone). Instead, the Facilities Plan recommended that Moraine Park connect to the Granby Sanitation District and send its effluent by gravity to the proposed treatment plant. This plan would also remedy the substandard system now under public health department censure (Reference 95).

## Utility Service Systems

Utility service systems operating in Grand County include electricity, water, natural gas, sewerage, solid waste management and telephone.

### Electricity--

Mountain Parks Electric, Inc. supplies electrical service to Grand County. Their source of electricity is mostly hydro-power obtained from the Tri-State Generation and Transmission Company which serves 25 systems, including the Mountain Parks system. Arrangements for expansion lines have been made and will be completed by Spring, 1976. This expansion power will come from coal generation plants in Hayden and Craig. A new substation has been built in the Grand Lake area to offset some of the load on the Granby substation. Mountain Parks Electric, Inc. has indicated that the electrical supply is adequate to meet the present and future needs of the Grand County residents, including Innsbruck-Val Moritz (Reference 96).

### Water--

Water for Granby is provided by the town of Granby. Water is obtained both from wells and from the Fraser River. A new potable water treatment plant is now in operation and provides Granby with water drawn from the Fraser River west of the U.S. Highway 40 crossing bridge. This water is of excellent quality and is preferable to the groundwater, which has high iron and manganese concentrations (Reference 97).

The town of Granby has water rights to withdraw 0.1 cu m/per second [3.5 cu ft per second (cfs)]from the Fraser River. Rights to an additional .057 cu m/per second [2 cfs] are soon to be purchased. Water use by Granby is presently about 0.025 cu m/per second [0.9 cfs]; the new water treatment plant capacity is about 0.042 cu m/per second [1.5 cfs[, with provisions for doubling the capacity if the need arises. The developers of Val Moritz own the necessary water rights and would supply residents from wells near the Fraser River (Reference 97).

Natural Gas--

Natural gas is supplied to Grand County by the Public Service Company of Colorado, which distributes the gas throughout all of Colorado. The gas is distributed directly to customers by pipelines. The Public Service Company states that natural gas demands can only be met as long as the supply is available. There is a waiting period for new natural gas service in excess of one year. There are 20 requests on file in Grand County of which four or five are from Granby. The Company is presently serving about 300 homes (including mobile homes) in Granby and supplies gas for space heating to the Granby wastewater treatment plant. There is definitely a shortage of natural gas, as with all fossil fuels, and future requests for service will only be filled as supplies are available (Reference 98).

Sewerage--

The Granby Sanitation District maintains the present wastewater treatment facility, which does not consistently meet water quality discharge requirements set by the Water Quality Control Commission of the Colorado Department of Health (Reference 93). Residents in the planning area living outside of Granby use septic tanks. There are several septic tank service companies which provide service to people without access to the Granby sewer system (Reference 93). The planned recreational-residential development of Val Moritz is presently not within the Granby Sanitation District, but is currently negotiating to share the District's facilities.

Solid Waste Management--

Refuse and garbage disposal in the planning area not disposed of independently is handled by the Grand County Land Fill and Trash Removal Company, a private company which services the towns of Winter Park, Tabernash, Parshall, Grand Lake and the town of Granby. The company disposes of both residential and commercial wastes. Residential pickup is once weekly while commercial pickup is one to seven times a week, depending upon the load. The solid wastes are transported by packer trucks to one of two landfill dumps, situated respectively 2.4 km [1.5 mi] west of Granby and .8 km [.5 mi] west of Fraser, both on Highway 40. Four trucks and eight persons operate during the summer and two to three trucks with four or six persons, respectively, operate during the winter. No problems are anticipated by the company in handling future solid waste loads, including projected Val Moritz loads (Reference 100).

The Granby Sanitation District currently uses the County sanitary landfill site located 2.4 km [1.5 mi] west of Granby for disposal of the wastewater sludge (Reference 101). The Bureau of Land Management owns the landfill site and has stipulated that the site must be closed down by May 31, 1976 (Reference 102). The Grand County Board of Commissioners (Reference 81) has chosen a new site for disposal of the sludge. Studies for the acquisition of this new site, 4.8 km [13 miles] northwest of Granby, have been underway for the past three years. As of January 1976, the Planning Commission was negotiating with the owners for purchase of the tract. The new landfill will be available for use by the summer of 1976, pending approval by the State Health Department and the U. S. Environmental Protection Agency (Reference 81).

Telephone--

The Mountain Bell Telephone Company provides telephone service in Colorado. Service to the planning area is dependent upon the feasibility of laying telephone cables to areas of limited accessibility, such as isolated cabins distant from existing telephone lines.

## QUALITY OF LIFE

Life in and around Granby is dominated by its natural setting. Open range land, spectacular mountains, forests and streams abound. The local climate, clean air and the pastoral setting have made it a summer attraction spot for over 100 years, while its abundant fishing and hunting resources have drawn visitors for an even longer period of time. The high altitude, difficulty of access (particularly in winter), an economy traditionally based on agriculture, logging and seasonal tourism and not infrequent temperature changes of 28°C [50°F] within a twelve-hour period have combined to keep the resident population small.

However, the growing demand for recreational land, and the mobility provided by the automobile (and more recently by campers and trailers), has brought in an increasing number of visitors to the area. A small number of towns in the area, Granby prominent among them, have become focal points for many of these visitors, providing commercial facilities and accommodations.

Despite the increase in summer visitors, and the less marked growth in winter tourism as well, the human impact on the environment is still relatively small, though the potential impacts are great. Life in Granby is still dominated by the natural setting, a condition which makes the area attractive for those who choose to live there, as well as those who visit to enjoy the natural beauty or for hunting, fishing and other recreational opportunities.

The natural setting is assuming a growing importance to Granby's economic life. As noted elsewhere in this report, lodging accounted for more than double the business activity in 1968 compared to 1960. Second-home development has begun to appear in Granby.

Expansion of resources for visitors and full and part-time residents will affect the natural character of the region, though if controlled, these impacts can be mitigated and hopefully minimized. Hasty and thoughtless development can severely debase the existing quality of life, destroy the rural character which the residents have chosen, and cheat the newcomers of those very qualities they are seeking.

# SECTION IV

# ALTERNATIVES

The town of Granby (and possibly the nearby speculative development proposed by the Del Webb Corporation) is required to solve its future wastewater disposal problem in a cost-effective and environmentally sound manner. A number of alternative solutions have been proposed and are described and discussed in the following paragraphs. The discussion is prefaced by a brief description of the regulatory context within which the alternatives must be considered.

## REGULATORY CONTEXT

Regulatory efforts are directed toward definition and control of water quality in the natural environment and toward specification of quality levels for discharged wastewaters in relation to their particular receiving environments.

### Water Quality Standards

Standards for stream water quality are promulgated by the Water Quality Control Commission of the Colorado Department of Health (Reference 3). The Fraser River has been designated "water quality limited" by the Colorado Water Quality Control Division. Therefore, waste load allocations requiring nitrification and chlorine removal were determined to be necessary for the Granby facility in order to meet the stream standards. The segment of the Fraser River that would receive effluent from the proposed project is presently classified as a B1 stream; quality requirements for a stream of this type are shown in Table 29.

### Effluent Limitations - Discharge to Streams

The 1972 Amendments to the Federal Water Pollution Control Act entirely replaced the language of the existing Act--including the Water Quality Improvement Act of 1970.

The Act establishes as a national goal that by 1985 the discharge of pollutants into the navigable waters of the United States be eliminated and as an interim goal that by 1 July 1983 there be achieved, wherever attainable, water quality which provides for the protection and propagation of fish, shellfish and wildlife and provides for recreation in and on the water. To reach these goals, the Act requires

Table 29. SUMMARY OF COLORADO STATE WATER QUALITY STANDARDS[a]

| Parameter | Class | | | |
|---|---|---|---|---|
| | A1 | A2 | B1 | B2 |
| | Standard | | | |
| Settleable solids | free from | free from | free from | free from |
| Floating solids | free from | free from | free from | free from |
| Taste, odor, color | free from | free from | free from | free from |
| Toxic materials | free from | free from | free from | free from |
| Oil and grease | Cannot cause a film or other discoloration | Cannot cause a film or other discoloration | Cannot cause a film or other discoloration | Cannot cause a film or other discoloration |
| Radioactive material | Drinking water standards | Drinking water standards | Drinking water standards | Drinking water standards |
| Fecal coliform bacteria | Geometric mean of <200/100 mℓ from five samples in 30-day period | Geometric mean of <200/100 mℓ from five samples in 30-day period | Geometric mean of <1000/100 mℓ from five samples in 30-day period | Geometric mean of <1000/100 mℓ from five samples in 30-day period |
| Turbidity | No increase of more than 10 J.T.U. | No increase of more than 10 J.T.U. | No increase of more than 10 J.T.U. | No increase of more than 10 J.T.U. |
| Dissolved oxygen | 6 mg/ℓ minimum | 5 mg/ℓ minimum | 6 mg/ℓ minimum | 5 mg/ℓ minimum |
| pH | 6.5 - 8.5 | 6.5 - 8.5 | 6.0 - 9.0 | 6.0 - 9.0 |
| Temperature | Maximum 68°F; maximum change 2°F | Maximum 90°F; maximum change: streams - 5°F lakes - 3°F | Maximum 20°C [68°F]; maximum change: 1°C [2°F] | Maximum 32°C [90°F]; maximum change: streams 3°C [5°F], lakes 2°C [3°F] |
| Fecal streptococcus | Monthly average of <20/100 mℓ from five samples in 30-day period | Monthly average of <20/100 mℓ from five samples in 30-day period | ---- | ---- |

[a] Adopted on 19 March 1974; effective date - 19 June 1974.

Source: Colorado State Department of Health that waste discharges be of a specified, improved quality before release to the receiving water. To assure that the improved quality is attained, new authority is given to Federal and State governments to fully develop a national permit system to regulate the quality of discharged wastes.

The Act stipulates that effluent limitations for point sources other than publicly owned treatment works shall require the application of the best practicable control technology not later than 1 July 1977 and the best available technology by 1 July 1983. Effluent limitations for publicly owned treatment works must be based on secondary treatment or whatever higher level of treatment may be necessary to meet water quality standards by 1 July 1977 and shall require the application of the best practicable technology by 1 July 1983. Best practicable control technology is being interpreted by EPA as that level of control that will maintain compliance with applicable water quality standards. EPA's secondary treatment effluent requirements are shown in Table 30.

Table 30. FEDERAL SECONDARY TREATMENT EFFLUENT REQUIREMENTS

| Parameter | Unit | Value<br>weekly average | <br>monthly average |
|---|---|---|---|
| Biochemical oxgyen demand (five-day)[a] | mg/l | 45 | 30 |
| Suspended solids | mg/l | 45 | 30 |
| Ultimate biochemical oxygen demand | mg/l | - | - |
| Ultimate oxygen demand | mg/l | - | - |
| Fecal coliform | no./100 ml | 400[b] | 200[b] |
| pH | | 6.0 to 9.0 | |

[a] 85 percent removal is also required; in the case of a dilute influent, this requirement may be more restrictive than the effluent limitation.

[b] Geometric mean

In addition to the stipulations for point sources of pollution, Section 208 of the Act requires that areawide waste treatment management plans include a process to identify nonpoint sources of pollution and establish procedures for their control. Nonpoint sources of pollution include agricultural and silvicultural activities, urban runoff and construction activities.

In addition to EPA's requirements, the State of Colorado has established effluent limitations that apply to all discharges to surface waters. State requirements are shown in Table 31 and are reflected in the NPDES permit conditions for Granby.

Table 31. COLORADO STATE SPECIFIC LIMITATIONS FOR THE DISCHARGE OF WASTES

| | Effective period of limitations | |
|---|---|---|
| Parameter | 7-day average | 30-day average |
| $BOD_5$[a] | 45 mg/l[b] | 30 mg/l[b] |
| Suspended solids[a] | 45 mg/l[b] | 30 mg/l[b] |
| Fecal coliform | 400 org/100 ml[c] | 200 org/100 ml[d] |
| Residual chlorine | less than 0.5 mg/l[e] | |
| pH | 6.0 to 9.0[e] | |
| Oil and grease | 10 mg/l and there shall be no visible sheen | |

[a] 85 percent removal is also required; in the case of a dilute influent, this requirement may be more restrictive than the effluent limitation.

[b] Analysis of wastewater discharges for $BOD_5$ and suspended solids shall be based on specific sampling and interpretation methodology prescribed by the Colorado State Department of Health.

[c] The geometric mean of the values for a minimum of three grab samples collected during seven consecutive days.

[d] The geometric mean of the values for a minimum of three grab samples collected during 30 consecutive days.

[e] A single grab sample for residual chlorine, pH and oil and grease.

Source: Colorado State Department of Health.

As a result of analyses conducted as part of the basin plan for the area, a waste load allocation was performed for the Fraser River that led to the assignment of allowable emission rates of ammonia and chlorine residual for the Granby discharge which will ultimately be reflected in the permit conditions. The ammonia allocations are 6.8 kg/day [15 lb/day] in summer and 50.3 kg/day [111 lb/day] in winter. Residual chlorine allocation of 0.077 kg/day [0.17 lb/day] year round was established.

## Effluent Limitations - Disposal to the Land

At the present time there are no specific effluent requirements for land disposal of wastewaters. However, the Colorado Water Quality

Control Commission must approve all designs for land disposal systems. Furthermore, irrigation tail water quantities and total dissolved solid content must be monitored and recorded under a permit system now in effect. On the basis of actual practice in other parts of the country and the type of land likely to receive wastewaters in Granby (i.e., forested land or hay fields), an effluent treated to a level close to secondary is probably desirable.

## CONCEPTUALIZATION AND SCREENING OF SUB-ALTERNATIVES

The process of alternative development was conducted in two stages. First, all reasonable sub-alternatives for each part of the complete wastewater management system were identified and evaluated in a preliminary manner to determine their applicability to local conditions. Second, the more promising sub-alternatives were used as building blocks in the development of promising total systems, which were then evaluated in detail.

The groups of sub-alternatives evaluated for Granby include wastewater source control methods, wastewater treatment methods, effluent disposal or reuse modes and sewage sludge disposal methods. Sizing of system components is a very important aspect of the alternative development process.

## SOURCE CONTROL SUB-ALTERNATIVES

Potential methods of controlling waste quality and quantity at its source, upstream of the treatment facility, are described in this section.

### Wastewater Generation Rates

On the basis of information gathered during facilities planning in the course of the infiltration-inflow analysis, it is apparent that normal residential wastewater generation rate in the town of Granby is approximately 400 l [100 gal] per capita per day after adjustments are made to account for infiltration and the influx of visitors. This rate is close to the national average and cannot be regarded as excessive.

Water use rates can be reduced by installing water meters and charging for volume of water used rather than charging a flat rate. Studies in California (Reference 103) have indicated, however, that in single-family residential settings only the use of water outside the house for irrigation is price-elastic. Thus, the volume of water used inside the house that finds its way into the sewer cannot be reduced substantially through pricing mechanisms.

Although every effort should be made to prevent careless use of water, it is apparent that in Granby the relatively low rate of water use at present allows little room for amelioration of the waste disposal problem by reduction of the rate of wastewater generated. All alternatives synthesized for the Granby wastewater management systems are based on the assumption of continued moderate rates of water use.

## Infiltration and Inflow

Investigations carried out during the summer of 1974 (Reference 1) indicated that infiltration into the Granby collection system is excessive and that repair of the leaking sewers is more cost-effective than is treating the larger volume of water. Thus, all alternatives considered for Granby assume that infiltration into the existing collection system will be significantly reduced and that new collectors for Val Moritz will be designed and constructed to minimize infiltration.

## WASTEWATER TREATMENT/DISPOSAL SUB-ALTERNATIVES

A number of wastewater treatment and disposal options for Granby are described in the following paragraphs. Regardless of the ultimate disposal mode, it is assumed that all alternatives must comply with all applicable local, State and Federal regulations.

## Treatment and Discharge to Surface Waters

Current State and Federal regulations dictate that any discharge to the surface waters must receive at least secondary treatment. In this case it has been determined, as a result of analyses made as part of the Basin Plan (Reference 2), that the Granby discharge must in addition be nitrified to a greater degree than that normally attained by conventional secondary treatment. A more detailed discussion of the nitrification requirement is included as Appendix C.

It is apparent that, whatever treatment process may be adopted, the effluent produced must meet minimum permissible quality requirements for all alternatives involving stream discharge and that their characteristics are thus likely to be similar. Nonetheless, differences in reliability and flexibility among treatment methods exist, especially under the severe climatic conditions encountered in Granby. These differences may be potentially important insofar as impacts upon the receiving waters are concerned. In addition to differences resulting from different processes in the various critical parameters, the ability to handle transient loads, too, can vary from one process to another. Significant land use differences exist between land application alternatives and those involving mechanical plants and river disposal. In view of the unconventional nature of the Biodisc process recommended in the Facilities Plan (Reference 1), a brief discussion of that process and its ability to meet applicable effluent requirements is provided in Appendix D. In light of the potential problems of cold-weather operation expressed in Appendix D, further justification of the Biodisc design criteria should be presented by the District. There is little doubt that the Biodisc process can meet effluent requirements; it is rather a question of the appropriate plant size necessary to handle the maximum flow at the lowest expected influent temperature.

The facilities planning consultant reported that the existing plant cannot be expanded economically because of the age and condition of the structures, the repeated modifications made previously and the difficulty involved in enclosing the facilities in a covered building. The plant was originally built in 1955 and consisted of a *Clarigestor*, a trickling filter and a secondary clarifier. Substantial modifications were made in 1968 in an effort to improve the plant. The *Clarigestor* was converted to an activated sludge contact tank, the trickling filter to a secondary clarifier and the secondary clarifier to a chlorine contact tank, and an aerobic digestor was added. The modifications were, however, intended only as an interim measure; consequently, high quality construction methods were not used, and the system remains far from ideal (Reference 22).

For these reasons it appears that expansion and further modification of the existing facilities to handle higher flows is not a promising option.

The facilities planning consultant considered four possible treatment plant site locations, as shown in Figure 10 (Section III). An additional site, proposed by the superintendent of the Granby Sanitation District, offers some distinct advantages and has been added to the analysis. This site is located near Windy Gap about 1.2 km [.75 miles] north of the junction of Highway 40 and Highway 125, also shown in Figure 10.

The five sites are similar with respect to most criteria; however, they do have some significant differences in the areas of cost, aesthetics, flood risk and dilution available in the stream at the discharge site. A qualitative comparison of the five sites with respect to these parameters is shown in Table 32. It is apparent that there is little significant difference between the first four sites; for the purpose of further analysis, a system employing Site 3 will be analyzed but can be taken to represent any one of Sites 1 through 4. Site 5 is significantly different and will be carried through the analysis, mainly because the discharge of effluent would be made to the Colorado River rather than to the Fraser River.

Table 32. COMPARISON OF FIVE ALTERNATIVE SITES FOR WASTEWATER TREATMENT PLANT LOCATIONS[a]

| Site[b] | Aesthetic vulnerability[c] (odor and visual) | Flood hazard | Cost | Impact on receiving water |
|---|---|---|---|---|
| 1 | moderate | high | moderate | moderate |
| 2 | high | high | low | moderate |
| 3 | high | high | low | moderate |
| 4 | high | high | low | moderate |
| 5 | low | low | high | low |

[a] Designations for comparison of alternatives are relative rankings on a three-point scale where low is least potentially damaging (or is least expensive), high is most potentially damaging (or most expensive) and moderate is somewhere between the two extremes.

[b] Alternative site locations are shown on Figure 10 (Section III).

[c] From Colorado State University Carrying Capacity Study.

## Treatment and Crop Irrigation

Wastewaters can be reclaimed and used as supply waters for various purposes such as industrial cooling, recreational lakes or agricultural irrigation. The Granby area presently has no industries, though future light industrial development is anticipated as the town has recently encouraged such development through purchase of land earmarked for industrial use. Water-oriented recreation is currently provided by the Three Lakes system in eastern Grand County.

Agricultural application of wastewater effluent is currently practised in many communities for the purpose of minimizing stream pollution and recycling nutrient resources from effluent discharges (References 104, 105, 106 and 107). The feasibility of agricultural wastewater application is determined by many factors, including wastewater characteristics, physical requirements of the irrigation system, length of the growing season, crop requirements, legal jurisdictions and environmental effects.

On the basis of a preliminary analysis of these factors, it is apparent that seasonal irrigation of croplands should remain an option for beneficial reuse of wastewaters in the Granby area although the growing season is short.

The length of the growing season is generally defined as the period when the maximum temperature stays well above the freezing point for an extended period of days (Reference 108). Land application is possible at low temperatures if the effluent does not freeze in distribution or spraying equipment. Little purification occurs at temperatures near or below freezing, and the effluent may freeze into mounds of ice at points of application, possibly harming the vegetation (Reference 108).

Freeze data for the Grand Lake Weather Station (Table 4, Section III) show the mean number of days between the last spring freeze and the first fall freeze to be 41 days for 0°C [32°F] and 101 days for -2.2°C [28°F]. Table 5 (Section III) shows that there is an average of 112 days per year, mostly in summer, when the temperature does not drop below freezing. However, a frost-free season of less than 125 days limits crop production potential. Because of the short growing season in Granby, crop irrigation is presently conducted for two months (June and July) per year (Reference 22). In spite of this short growing season, it is possible to extend the irrigation period for as long as five months during which evaporation rate exceeds precipitation (Figure 5, Section III). Such extension would involve adequate controls to match irrigation with potential evapotranspiration.

A further consideration is that the waters of the Fraser and Colorado rivers are subject to downstream water rights and to the 1973 Minimum Flow Regulation (Reference 109). The loss of effluent to evaporation has been cited as a possible violation of water rights in precluding reuse of the water downstream (Reference 1). Wright and Toren (Reference 107), however, are of the opintion that the Colorado Water Law Appropriation Doctrine "is very flexible and permits almost anything to be devised as long as adverse material injury is not caused to owners of other vested water right appropriations."

Two alternative sites were identified in the Facilities Plan and are shown in Figure 10 (Section III). A detailed description of the sites is given in Section III under Environmental Setting. In general, the impacts associated with use of the two adjacent sites are similar. Because the site alongside the Colorado River (Site 1) involves a higher risk of stream pollution as a result of surface runoff, the Granby Mesa site (Site 2) might be considered preferable from an environmental point of view.

The Colorado River site (Site 1) has the advantage of already being used for agricultural purposes; the canal system used to divert Colorado River waters could be employed to distribute reclaimed wastewater. It may be difficult, however, to persuade the farmers to accept treated wastewater rather than river water as an irrigation water source.

Use of the Granby Mesa (Site 2) would be more costly because of its higher elevation and the need to construct distribution facilities. Because the area is not critically water-short and to date land owners on the Mesa have not chosen to use their land for irrigated agriculture, it may be that the Sanitation District will itself have to purchase the land and develop it as cropland. In that case, the high costs involved would probably make utilizaton of the Mesa site infeasible. Furthermore, elk use and need portions of Granby Mesa as critical winter range (See Figure 12, Section III) and might be disturbed more by an irrigated regime than by dry-farmed agriculture.

For these reasons, use of the Colorado River site is assumed in subsequent evaluation. Further considerations regarding use of effluent for agricultural irrigation are presented in Appendix E.

## Land Disposal of Wastewaters

Land disposal of wastewaters represents the use of soil as a receiving medium for wastewater without direct beneficial reuse. The spray irrigation process for this type of land application has been claimed by certain investigators to have fair results in cold climates and to be acceptable for woodland areas (Reference 110). Forest irrigation in general has greater suitability in cold-weather climates than does agricultural irrigation; however, the closed nature of the ecosystem may tend to foster the buildup of nitrates and other constituents found in the effluent over long periods of time. Besides increasing the moisture and humidity of the microclimate, irrigation probably would influence plant succession by favoring more water-tolerant species (Reference 110).

High groundwater levels in the low-lying areas near the rivers limit the number of suitable disposal sites available. Two forested areas were identified in the Facilities Plan (Reference 1) as suitable for land disposal of wastewaters and are shown in Figure 13 (Section III). Detailed descriptions of the two sites are given under Environmental Setting in Section III.

The feasibility of land application of wastewaters generally is governed by the same factors as those for crop irrigation, with differences in the length of the growing season, the absence of crop selection and more site-specific environmental effects.

The growing season on nonagricultural lands is slightly longer. The ground usually thaws out in early May and does not refreeze until October or November. Thus, forest land application could be conducted for a longer period of time than could crop irrigation.

Two forested areas were identified in the facilities plan as suitable for land disposal of wastewaters and are shown in Figure 13. Site 2, east of the planning area boundary is less attractive as a disposal site because of its proximity to streams and its importance as an elk and deer range. Site 1, 8 km [5 miles] south of Granby, is a possible land disposal site and will be further evaluated in the following section. More detailed considerations regarding land disposal of effluent are presented in Appendix E.

## SLUDGE DISPOSAL SUB-ALTERNATIVES

Residual solids from sewage treatment plants are usually stabilized, dewatered and disposed of to the land. The environmental impacts associated with alternative stabilization and dewatering processes are relatively insignificant and will not be discussed in detail here. The ultimate disposal method proposed in the Facilities Plan (Reference 1) for digested sludge is burial in a sanitary landfill. Grand County is experiencing a large problem in establishing landfilling sites to replace the existing Granby site, whose lease from the U.S. Bureau of Land Management has lapsed.

Provided the landfill is operated in accordance with controlled sanitary standards (Reference 111), the environmental impact of this action will be slight. No preferable alternatives are evident. It is expected that the facilities planners will conduct a more thorough study of sludge management alternatives prior to design and construction of the wastewater treatment plant.

It should be pointed out that the Sanitation District reports local opposition to land application of effluent and sludge. Again, a detailed site specific study including negotiations for an actual site, would have to be done before a decision can be made on a land treatment scheme for sludge disposal. This question though beyond the scope of this EIS, is a legitimate one that will have to be examined before any final project design is complete.

## SYNTHESIS OF PROMISING ALTERNATIVES

On the basis of the foregoing analysis, the following six alternatives are identified as worthy of further consideration.

### Alternative 1 - No Action

This alternative involves the maintenance of the existing secondary treatment plant and continued discharge of effluent to the Fraser River. It does not attempt to provide sewage treatment service for any extensive future development. Assuming implementation of an effective infiltration control program, the existing plant could provide adequate service for a maximum of 2,000 permanent residents and 1,000 visitors.

### Alternative 2 - Construct New 5,700 cu m per day [1.5 mgd] Treatment Plant with Discharge to Fraser River

A new secondary wastewater treatment plant would be constructed on Site 3 adjacent to the existing facility. Effluent would be discharged to the Fraser River close to the present discharge point.

### Alternative 3 - Construct New 5,700 cu m per day [1.5 mgd] Treatment Plant with Discharge to Colorado River

A new secondary wastewater treatment plant employing nitrification and either chlorination-dechlorination or an alternate means of disinfection would be constructed on Site 5 (Figure 10, Section III) near Windy Gap. Effluent would be discharged to the Colorado River through a short (1.2 km [0.75 mile]) outfall.

### Alternative 4 - Treatment and Land Disposal

Raw wastewaters would be pumped to a 24- to 32-hectare [60- to 80-acre] lagoon system in the Arapaho National Forest. During the summer and fall, when the ground is not frozen, effluent from the lagoons would be chlorinated and sprayed onto the land at a rate of approximately 0.64 cm [0.25 in.] per day.

### Alternative 5 - Treatment and Crop Irrigation

Raw wastewaters would be pumped to a 24 to 32 hectare [60 to 80 acre] lagoon system on Granby Mesa. During the two- to three-month growing season, or the five months when evaporation exceeds precipitation, chlorinated effluent would be used for spray irrigation of hay fields.

### Alternative 6 - Staged Construction of New Facilities

Alternatives 2, 3, 4 and 5 all involve immediate construction of wastewater management facilities to handle the entire 1990 projected flow. Because the population growth and flow projections are based on speculative development of Val Moritz and involve a high degree of uncertainty, it is possible that a large and costly facility might be built but never used to capacity. For this reason, an alternative involving staged construction of facilities designed to match available capacity more closely with actual demand is evaluated alongside the other alternatives.

All four technical alternatives could be staged. Furthermore, the implications of staging with respect to costs and growth-inducement potential are similar for all of these alternatives. Therefore, a single staged alternative, a staged version of Alternative 2, is analyzed as a representative example in the following sections in detail. For comparative purposes, three stages are envisioned, each with an incremental capacity of 1,900 cu m/day [0.5 mgd].

## COSTS AND PERFORMANCE

Each water quality management alternative must be evaluated with respect to three major groups of factors: cost, system performance and environmental impact. The detailed analysis of the environmental impact of each alternative is presented in Section V. A discussion of the relative cost and performance of the alternative systems is presented below.

### Costs

Capital and operation and maintenance costs for each alternative are shown in Table 33. In most cases, the costs are quoted directly from the Facilities Plan; cost calculations and supporting data provided by the facilities planning consultant have been reviewed and found to be within a reasonable range. Possible exceptions are discussed in the following paragraphs.

Table 33. COSTS OF ALTERNATIVE WASTEWATER MANAGEMENT SYSTEMS

(dollars)

| Alternative | Total capital cost | Annual O & M cost at capacity |
|---|---|---|
| 1 | - | 40,000 |
| 2 | 2,564,500 | 80,000 |
| 3 | 3,703,500 | 95,000 |
| 4 | 4,140,000 | 110,000 |
| 5 | 3,000,000 | 65,000 |
| 6 | 4,800,000 | 80,000 |

In the case of alternatives 4 and 5, disposal to forested areas and agricultural irrigation, it was assumed by the facilities planning consultant that storage during the nongrowing season would be in lined pond systems. If the storage were maintained in unlined ponds, a considerable proportion of the stored wastewater would percolate into the ground, realizing a saving in total pond acreage requirements and in the cost of lining. It is estimated that approximately $1 million could be trimmed from the capital cost of alternatives 4 and 5 in this manner. However, it should be recognized that unlined ponds can be used only if detailed field investigation indicates no threat to groundwater quality from percolating wastewaters.

To compare the staged alternative (Alternative 6) with an unstaged alternative (Alternative 2), it is necessary to calculate costs in terms of total present worth; that is, the present worth of all payments necessary to construct and operate a system between now and 1990 less the present worth of the salvage value of the system in 1990. Four scenarios were considered:

Scenario 1 - Alternative 2: Val Moritz develops as planned
Total Present Worth = $ 2,890,000

Scenario 2 - Alternative 2: Val Moritz fails to develop
Total Present Worth = $ 2,827,000

Scenario 3 - Alternative 6: Val Moritz develops as planned
Total Present Worth = $ 2,917,000

Scenario 4 - Alternative 6: Val Moritz fails to develop; only first stage of treatment is built
Total Present Worth = $ 1,570,000

This clearly demonstrates the advantage of maintaining flexibility in the staging of facilities. Future area residents would be spared paying for an under-utilized system should population growth rates remain low.

Further evaluation of the Biodisc process design criteria used in preparing the cost analysis for alternatives 2, 3 and 6 may require enlarging the Biodisc unit process size but should not affect other unit components in the overall wastewater treatment system. A 1,900 cu m/day [0.5 mgd] increase in rotating disc unit capacity would require an estimated additional capital expenditure of $154,000.

## System Performance

Each of the alternative systems would be designed to meet certain performance standards. In some cases, stream discharge for example, satisfactory performance is defined by numerical effluent quality requirements; in others, where discharge requirements are not specified, satisfactory performance is simply an acceptable and environmentally sound solution to the waste disposal problem. The relative performance of the alternatives is a nonquantifiable consideration. It has been assumed that with careful design all proposed new systems can meet expected effluent quality requirements.

One aspect of system performance is reliability. Alternatives 1, 2, 3 and 6 all involve biological treatment and stream discharge. The ability to produce a consistently high quality effluent from a biological system depends on many factors such as variability of incoming waste quality, the skill of the operating staff and temperature. At Granby it can be expected that process reliability in properly designed facilities will be good, with the exception of nitrification of the effluent. During the winter months, the ammonia removal efficiency of the biological systems will drop significantly. This is due to reduced biological reaction rates at low temperatures and may be compensated through increases in biological reactor size. The lowered ammonia removal efficiency during the winter months, however, coincides with a less restrictive ammonia effluent requirement in those months, thus enhancing the ability of the treatment system to meet the requirement.

The rotating disk process proposed in the Facilities Plan is reputed to enjoy great stability and simplicity of operation with typical domestic wastewaters. Shock loadings of toxic materials or very low wastewater temperatures can reduce process efficiency, more notably in ammonium nitrogen removal, as discussed in Appendix D.

The reliability of land disposal and irrigation alternatives will be good. Though not formally adopted by the Colorado Water Pollution Control Commission, Colorado generally requires secondary treatment of effluent before it is used in land treatment. In general, the long detention time in the storage ponds should ensure that effluent is as good or better than secondary effluent. Land disposal and irrigation alternatives are, due to the necessary treated effluent storage and delivery systems, more complex than simple treatment and stream discharge. There may be greater opportunity for equipment malfunction or human error.

With regard to the implementability of the alternatives, alternatives 4 and 5, involving land application, can be expected to be somewhat more difficult to implement than the stream discharge options. This is because implementation of Alternative 4 would require the permission of the U.S. Forest Service or the Bureau of Land Management, depending on the site selected, to dispose of wastewaters on Federal land. In either case, an Environmental Impact Statement would be required since land application involves the major use of Federal land. Implementation of Alternative 5 would be contingent upon the acceptance of treated wastewater as an irrigation water source by farmers. An arrangement would have to be made with farmers to accept the effluent, and commitments received for extended time periods, to justify the laying of delivery pipelines. Some public relations work may be necessary to gain farmers' acceptance of the treated wastewaters.

## COST ANALYSIS

Since the benefits of the different facilities have been treated elsewhere in this report, the analysis presented in this section will focus on a comparison of the different costs, using the recommended techniques for reducing all capital and operating costs to a present value and an average annual equivalent cost.

Of the six project alternatives under consideration in this study, four represent distinctly different wastewater treatment plant facilities. One of the six (alternative 1) is the no-project alternative, while alternative 6 is essentially a phased construction version of alternative 2. Both alternatives 6 and 2 represent construction of a new facility adjacent to the present wastewater treatment facilities with discharge into the Fraser River, using the biodisc method of treatment. Associated with the four different plant types are four different levels of capital and operating costs. All four different general facilities proposed (alternatives 2, 3, 4 and 5) meet the minimum water quality requirements and hence can be considered in that sense to have equivalent benefits. All four are also designed to meet the present and projected needs of the permanent Granby population as well as the contemplated increased demand from second home development at the nearby Val Moritz project.

The analysis is presented in two steps because the comparison of different general plant types (alternatives 2 through 5, all unphased) can be made in a summary form, while the comparison of alternative modes of construction in the same plant type (alternatives 2 and 6) requires much more detailed treatment of the change in operating and capital costs over time.

The first step in the analysis is therefore to compare alternatives 2, 3, 4 and 5 to identify which of the four represents the lowest cost on a present worth basis. The second step in the analysis is focused on a comparison of alternative 2, which on the basis of general plant types seems preferable to the other general plant alternatives, with alternative 6, which is the same plant built in three stages.

The considerations of phased versus unphased construction are particularly important since the requirement for a 5,700 cu m/day [1.5 mgd] facility is predicated on the continued sales at Val Moritz. Since there can be no certainty regarding the projected development schedule or even the continued growth of Val Moritz, careful consideration must be given to the possible cost benefit to the Granby Sanitation District of building a smaller facility fully adequate to meet the present and projected needs of the permanent population without Val Moritz.

## Summary Comparison of Plant-Type Alternatives

The four different plant-type alternatives are shown in Table 34 together with estimates of their capital cost, land costs and operating and maintenance costs. In all cases costs are quoted in 1976 dollars and in all cases the operating and maintenance costs quoted are those at full volume operation in 1990. For the purpose of this summary analysis, no separate treatment is made of the additional funds required for equipment sinking fund allocation.

The recommended present worth methodology requires the combination of the present worth of the capital costs with the present worth of the operating and maintenance costs over a 15-year period. These two numbers together generate total present worth which in turn can be converted into an average annual equivalent cost. These calculations are summarized in Table 34 for the four different plant alternatives. It is clear from an examination of this table that there is a fairly wide range in capital costs from $2.56 million for alternative 2 to $4.14 million for alternative 4. Operating and maintenance costs range from $65,000 per year to $110,000 per year. Alternative 2 has the lowest capital cost and the second lowest operating and maintenance cost. The present worth of alternative 2 is $2,865,000, the lowest of the four alternatives. Also, the average annual equivalent cost of alternative 2 is the lowest at $376,700 per year.

## Comparison of Alternatives 2 (Unphased) and 6 (Phased)

The summary comparison of general plant types indicates that alternatives 2 and 4 are the least expensive. Alternative 2, construction of a new wastewater treatment facility adjacent to the present facility with discharge to the Fraser River, appears preferable to alternative 4 because it is slightly less expensive and probably more acceptable to local residents. It should be pointed out that if the ponds were not lined for the land treatment alternates the cost of these would be significantly less. Unlined ponds could, however, be unacceptable to the State Health Department because of their potential impact on groundwater. The question remains whether the plant should be built in a single stage of a 5700 cu m/day [1.5 mgd] facility (alternative 2) or in three 1900 cu m/day [0.5 mgd] increments (alternative 6). A comparison of the cost effect of phased and unphased construction for this plant requires a further comparison of whether or not the Val Moritz land development near Granby continues to develop and thereby creates demand for additional sewer facilities. Several critical assumptions are required with respect to the development pattern of Val Moritz in order to permit a comparison. Most notable among these is the fact that Val Moritz (or its owners) and the Granby Sanitation District will share in the capital cost of construction and the subsequent operating and maintenance costs on some sort of fixed basis. The assumption made herein is that if Val Moritz is part of the analysis and therefore its demand and revenue factors are to be included, it will contribute 70 percent of the capital and operating and maintenance costs and Granby Sanitation District will contribute 30 percent. These ratios are predicated on a rough approximation of the requirements generated by Val Moritz when fully developed and the indigenous or local requirements of the

Table 34. SUMMARY COMPARISON COSTS FOR PLANT TYPE ALTERNATIVES

(dollars)

| Cost factor | Alternative 2, Fraser River | Alternative 3, Colorado River | Alternative 4 forest land application | Alternative 5, irrigated farm land application |
|---|---|---|---|---|
| Capital cost[a] | | | | |
| Total | 2,564,500 | 3,703,500 | 4,140,000 | 3,000,000 |
| Land | 35,000 | 35,000 | 0 | 175,000 |
| Local share (20% + land) | 540,900 | 768,700 | 828,000 | 740,000 |
| O & M[a] at full operation | 80,000 | 95,000 | 110,000 | 65,000 |
| Present worth[b] | 2,865,100[c] | 3,955,600 | 4,484,400 | 2,984,000 |
| Average annual equivalent cost | 376,700[c] | 520,100 | 598,600 | 392,300 |

[a] Cost estimates by NHPQ and Engineering-Science, Inc.

[b] Present worth = capital cost plus present value of O & M costs over 15 years discounted at 10 percent minus present worth of salvage value in 15 years (also discounted at 10 percent), where salvage value equals 1/2 (assuming 30-year life) of initial capital cost (excluding land and Facilities Plan) plus land cost.

[c] Differs slightly from more detailed estimate in Table 35 due to simplified treatment of O & M cost and exclusion of pquipment sinking fund.

Granby Sanitation District excluding Val Moritz. For purposes of this phasing cost analysis, four different scenarios are considered:

I. Construction of the full 5,700 cu m/day [1.5 mgd] plant (unphased) in 1976; with full-scale rapid development of Val Moritz as projected in the Facilities Plan.

II. Construction of the full 5,700 cu m/day [1.5 mgd] plant (unphased) with little or no subsequent development by Val Moritz.

III. Construction of a 1,900 cu m/day [0.5 mgd] plant with the balance of the 5,700 cu m/day [1.5 mgd] full capacity to be accounted for in two additional phases, the first in 1979 and the second in 1986; again assuming full and rapid development of Val Moritz according to projections in the Facilities Plan.

IV. Construction of the first phase only (1,900 cu m/day [0.5 mgd] of the facility; with no consideration of Val Moritz and no further sales or development by that project.

Present worth and annual equivalent cost calculations do not specify who bears the cost of the plant. Consequently, this analysis can be undertaken without any assumptions regarding the outcome of the negotiations currently underway between Val Moritz and the Granby Sanitation District as to sharing both capital costs and operating and maintenance costs. The comparison of the phased and unphased alternatives is identical in this respect to the comparison of alternative plant types.

In several other important respects, however, the phased versus unphased analysis is more complex, primarily because of the need to consider more precisely the effect of costs over a time period. In the unphased alternative, all capital costs will be paid at the beginning of the project and the operating costs will gradually increase to the full level by 1990. For the phased alternative, capital costs will be paid in three separate stages. This will result in a lower present worth, somewhat offsetting the higher total cost of the phased program. At the same time, operating and maintenance expense and equipment sinking funds will start out at a lower level and will only increase as the subsequent increments to the plant are added. The results of the present worth calculations together with the average equivalent cost calculations are summarized in Table 35.

Table 35. PRESENT WORTH AND ANNUAL EQUIVALENT COST (dollars)

| Scenario | | Present worth | Average equivalent cost |
|---|---|---|---|
| I | Unphased, with Val Moritz | 2,890,000 | 380,000 |
| II | Unphased, without Val Moritz | 2,827,000 | 371,000 |
| III | Phased, with Val Moritz | 2,917,000 | 383,000 |
| IV | Phased, without Val Moritz | 1,570,000 | 206,000 |

The foregoing summary, the detailed results of which are presented in Table 36, demonstrates that the phased alternative is in some important economic respects preferable to the unphased. Without the development of Val Moritz, even assuming that Val Moritz contributes 70 percent of the capital costs while not contributing to operations and maintenance, the present worth is substantially lower in the phased example. Total present worth on the phased plant without Val Moritz is $1,570,000 and in the unphased plant is $2,827,000. A parallel reduction in annual average equivalent costs is also noted with the cost dropping from $372,000 per year (unphased) to $206,000 per year (phased).

More significant is that even with the full development of Val Moritz under the original and apparently optimistic assumptions used in the Facilities Plan, there is little to distinguish the present worth or annual average equivalent costs for the phased and unphased alternatives. While the phased alternative is slightly more expensive in terms of present worth ($2,917,000) versus $2,890,000), this difference is less than 1 percent of the total present worth and is well within the tolerance of the cost estimates.

Given the essentially trivial difference between the costs of the phased and unphased alternatives with Val Moritz, the substantially greater uncertainties associated with the full development of Val Moritz clearly militate against the construction of the unphased plant from a purely economic point of view. The penalty exacted for adopting a phased approach if Val Moritz does develop as rapidly as originally projected seems more than warranted by the potential for substantial growth created by the existence of a 5700 cu m/day [1.5 mgd] plant in the event that Val Moritz fails to develop as originally projected. Even more significant is the possibility that, were Val Moritz to withdraw from its development, there would be considerable financial pressure on the Granby Sanitation District to permit or even encourage other developers to come in and engage in extensive recreation-second home developments to generate needed revenues.

Table 36. SUMMARY OF CAPITAL AND OPERATING COSTS WITH COST/BENEFIT COMPUTATION

| Cost factor | Unphased | | | | Phased | | | |
|---|---|---|---|---|---|---|---|---|
| | With Val Moritz | | Without Val Moritz | | With Val Moritz | | Without Val Moritz | |
| | 1976 $ | P.V. @ 10%[a] | 1976 $ | P.V. @ 10%[a] | 1976 $ | P.V. @ 10%[a] | 1976 $ | P.V. @ 10%[a] |
| Capital cost[b] | | | | | | | | |
| Phase I (1976) | | | | | 1,332,500[c] | 1,332,500 | 1,332,500 | 1,332,500 |
| Phase II (1979) | | | | | 1,270,000 | 943,170 | - | - |
| Phase III (1986) | | | | | 1,270,000 | 489,640 | - | - |
| TOTAL | 2,564,500 | 2,564,500 | 2,564,500 | 2,564,500 | 3,872,500 | 2,776,310 | 1,332,500 | 1,332,500 |
| Operating & maintenance cost[d] | | | | | | | | |
| 1976 (base)cost | 60,000 | 456,365 | 60,000 | 456,365 | 40,000 | 304,243 | 40,000 | 304,243 |
| Phase increments | | | | | | | | |
| Phase II (1979) | | | | | 10,000 | 51,192 | | |
| Phase III (1986) | | | | | 10,000 | 14,615 | | |
| Growth increment (by 1990) | 20,000 | 63,096 | - | - | 20,000 | 63,096 | 10,000 | 31,548 |
| 1991 total cost | 80,000 | | 60,000 | | 80,000 | | 50,000 | |
| Equipment sinking fund[b] | 15,000 | 114,091 | 15,000 | 114,091 | 11,300 | 79,565 | 7,000 | 53,243 |
| Salvage value in 1991[e] | ⟨1,286,000⟩ | ⟨307,858⟩ | ⟨1,286,000⟩ | ⟨307,858⟩ | ⟨1,552,933⟩ | ⟨371,760⟩[f] | ⟨635,000⟩ | ⟨152,014⟩ |
| TOTAL PRESENT VALUE | | 2,890,194 | | 2,827,098 | | 2,917,261 | | 1,569,520 |
| Average annual equivalent cost[g] | | 379,985 | | 371,689 | | 385,543 | | 206,351 |
| Granby allocation | | | | | | | | |
| Land cost | 35,000 | | 35,000 | | 35,000 | | 35,000 | |
| Construction cost (full) | 151,770 | | 151,770[h] | | 229,800 | | 259,500 | |
| TOTAL CAPITAL COST | 186,770 | | 186,770 | | 264,800 | | 294,500 | |
| Operating & maintenance (avg) | 21,000 | | 60,000 | | 18,400 | | 45,000 | |
| Equipment sinking fund (avg) | 4,500 | | 15,000 | | 3,390 | | 7,000 | |
| Debt service on capital (avg) | 19,736 | | 19,736 | | 21,051 | | 31,120 | |
| TOTAL ANNUAL COST | 45,236 | | 94,736 | | 42,841 | | 83,120 | |

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[a] Present value discounted at 10 percent per annum.

[b] Estimates (in 1976$) by Engineering-Science, Inc. (adapted from Nelson, Haley, Patterson and Quirk).

[c] Subsequent phases exclude land ($35,000) and Facilities Plan ($27,500) cost.

[d] Estimate (in 1976$) by NHPQ confirmed by Engineering-Science, Inc.

[e] Predicated on average 30-year life (straightline) for plant and equipment.

[f] Salvage (or resale) value for phased construction computed to same total base cost as unphased with adjustment for two newer phases having higher remaining value in 1991.

[g] Annual "payment" required to amortize "total present value" over 15 years at 10 percent.

[h] Assumes onl6 30 percent; i.e., Val Moritz terminates after construction since termination prior to construction would compel smaller plant.

## Reconsideration of Growth Projection

The foregoing analysis comparing alternatives has been based on the original projections of Val Moritz growth, which indicate a peak population of approximately 12,000 at Val Moritz and 5,000 elsewhere in the district by 1990. These are the estimates originally developed by the facilities planners and others and represented the best available information in 1974, at which time sales at Val Moritz were high. Subsequent cessation of sales, changes in the national economy, and deterioration of market conditions in the recreation and second home market clearly warrant a reexamination of some of these assumptions. As indicated in the Growth Inducing Impacts section of this report, a more modest and independently generated projection of population growth in the Granby Sanitation District service area would indicate approximately 9,700 peak population (vs. 17,000) by 1990 with approximately 7,200 seasonal peak population at Val Moritz (vs. 12,000).

This suggested downward revision in growth forecast has an important impact on the requirements for additional wastewater treatment capacity. As shown in Table 37, without Val Moritz, projected system requirements, as measured in cubic meters per day of influent, would only range between 460 cu m/day [.12 mgd] and 680 cu m/day [.18 mgd] based on the present population of the town of Granby and its projected endogenous growth.

If the impact of Val Moritz, through both seasonal resident population and induced employment, is added to the base projection for Val Moritz, influent levels rise sharply. If influent is estimated at 0.4 cu m/day [100 gpcd] for all residents, seasonal and otherwise, the total requirement would be 3,700 cu m/day [.97 mgd] by 1990. If, instead, a lower figure is used for seasonal population, 0.2 cu m/day [60 gpcd] per person, as proposed in the Facilities Plan, the total demand even in 1990 would only be 2600 cu m/day [.683 mgd]. It is clear from this analysis that with the revised base projection for Val Moritz, only two increments of 1,900 cu m/day [0.5 mgd] would be required for the proposed plant through 1990, with the second not being needed until approximately 1984 or 1985.

If, instead, the reduced projections for Val Moritz growth are used, total demand, even assuming a uniform 0.4 cu m/day [100 gpcd] requirement, would only be 2,700 cu m/day [.714 mgd] by 1990. Using the reduced requirement for seasonal residents, the total demand even in 1990 would exceed only by 190 cu m/day [.05 mgd] the capacity of a 1,900 cu m/day [0.5 mgd] facility which is proposed as the first phase.

This analysis, together with the results of the prior analysis based on much more optimistic assumptions about Val Moritz growth, clearly suggest that the construction of a 5700 cu m/day [1.5 mgd] plant at this time would be economically unwarranted under the assumptions made here. It is important to note that these assumptions exclude the impact of inflation and other political or business considerations that may enter into the negotiations between Val Moritz and the Granby Sanitation District.

## Table 37. PROJECTED SYSTEM REQUIREMENTS (INFLUENT) UNDER ALTERNATIVE ASSUMPTIONS ON VAL MORITZ DEVELOPMENT

| Basis for projection | 1975 | 1980 | 1985 | 1990 |
|---|---|---|---|---|
| No Val Moritz | | | | |
| Population[a] | 1,200 | 1,400 | 1,580 | 1,760 |
| Flow requirements @ 0.4 cu m/day/person[b] | 120,000 | 142,000 | 158,000 | 176,000 |
| Val Moritz at base projections | | | | |
| Peak population[a] | 1,200 | 2,380 | 5,500 | 9,710 |
| V.M. component[a] | | 900 | 3,600 | 7,200 |
| Flow requirements | | | | |
| @ 0.4 cu m/day/person[b] | 120,000 | 238,000 | 550,000 | 971,000 |
| @ 0.4 cu m/day/person and 0.2 cu m/day/seasonal[c] | 120,000 | 202,000 | 406,000 | 683,000 |
| Val Moritz with reduced projections | | | | |
| Peak population[a] | 1,200 | 2,060 | 4,220 | 7,140 |
| V.M. Components[a] | | 600 | 2,440 | 4,800 |
| Flow requirements | | | | |
| @ 0.4 cu m/day/person[b] | 120,000 | 206,000 | 442.000 | 714,000 |
| @ 0.4 cu m/day/person and 0.2 cu m/day/ seasonal[b] | 120,000 | 182,000 | 326,000 | 522,000 |

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[a] See Table 16

[b] per Facilities Plan [100 gpcd]

[c] per Facilities Plan [60 gpcd]

## Annual Cost to Granby Sanitation District

The foregoing analysis has dealt exclusively with the total cost of the project, independent of any federal subsidies and excluding any consideration of cost sharing between the District and Val Moritz. A potentially more meaningful analysis of the costs of the alternative systems would deal with the actual annual cash requirement for the Granby Sanitation District under the same assumptions.

The annual costs to the Granby Sanitation District will consist of the debt service on that portion of the capital investment which is not subsidized by Colorado or federal grants, and operating and maintenance costs, including in this case the equipment sinking fund as well.

The consideration of the annual cost to Granby must take into account whether or not the proposed project is built as an unphased 5700 cu m/day [1.5 mgd] facility or as a multi-phased facility beginning with a 1900 cu m/day [0.5 mgd] plant. It must also consider whether or not Val Moritz will be developed at all, and if so, whether development will proceed along the lines of the base projections or of the reduced projections with sales rate reduced by one-third.

The basis on which both the capital and operating costs of the facility will be shared between Granby Sanitation District and Val Moritz is necessary for this analysis. Specific information on this subject was not available, since negotiations between the district and Val Moritz are still underway. Based on prior analysis done in the Facilities Plan, it is assumed that Val Moritz will pay 70 percent of the initial capital costs of the facility, excluding land costs and the amount subsidized by the federal and state governments.

The situation with respect to operating and maintenance costs is less clear. Conversation with both parties to the negotiations do, however, reveal that the basis for such cost sharing will be related to the metered use of the facility by Val Moritz residents compared with other users in the Granby Sanitation District.

It is therefore clear that there will be no fixed cost sharing. The precise formula that will be used to establish cost sharing based on metered use is not clear. Under negotiation at this time are questions of premiums to be paid by Val Moritz, and what point in the year, e. g., peak season, off season, etc., the ratio of metered users to serve as the basis for cost sharing throughout the year is to be taken.

In the absence of clarification on this cost sharing issue, it has been assumed that the operating and maintenance costs will be shared in proportion to peak population served. This approach may tend to somewhat overestimate the share of costs borne by Val Moritz since seasonal residents may generate lower year-round demand per capita and proportionately lower metered use of the system. Partially offsetting this is the fact that much of the induced growth in Granby will be based on seasonal employment and it may well be that the share of metered use even on a seasonal basis will not differ substantially from the population ratios, since use factors in Granby proper will also probably decline sharply in the off season. Table 38 summarizes the population mixture between the two components of the service area and provides an approximation of the flow influent mixture. As shown in the table, the initial situation under both the base and reduced Val Moritz projections, is 100 percent Granby and 0 percent Val Moritz. Under the base Val Moritz projection, the Val Moritz share would rise to 74 percent by 1990, and would average approximately 47 percent over the fifteen-year analysis period. In the case of the reduced Val Moritz projection, the maximum share borne by Val Moritz in 1990 would be 67 percent, and would average only 39 percent over the life of the analysis period.

It is particularly interesting that through approximately half the time period, through both assumptions, Granby would bear more than one half the cost, even if the basis for charging were simply the total population independent of seasonal effect. If significant adjustments were made to reflect lesser seasonal use by Val Moritz compared to the higher continual use by Granby residents, the share borne by Granby would be even higher, probably remaining over 50 percent for ten years or more of the fifteen-year planning period.

Based on the shares of projected population served shown in Table 38, Granby would be paying an average of 81 percent of the operating and maintenance costs between 1975 and 1980 (the arithmetic average of 62 percent for 1980 and 100 percent for 1975). For the 1980-1990 period the average share would decline to approximately 49 percent; and for 1985-1990, it would be approximately 31 percent. Applying these average shares to the estimated debt service and operating and maintenance costs, a basis for estimating the actual cost to Granby is provided. These are shown in Table 39. In this table the unphased project is included largely for illustrative purposes and to further reinforce the conclusion that there seems to be no economic basis for unphased construction of the proposed project. As can be seen from the table, the cost to Granby with an unphased project would range from $80,500 to $94,700 in the first five years, and would decline to a range of $42,600 to $94,700 in the last five years. The higher figure in both cases is the cost borne by Granby if Val Moritz did not develop at all.

For phased construction the situation is somewhat more complex, since with Val Moritz it is clear that a second phase facility adding 1900 cu m/day [0.5 mgd] would be required prior to 1986. This would result in some increase in the debt service and operating and maintenance charges. The overall result to Granby would be costs of $53,400 - $55,800 at the beginning of the period with a 1900 cu m/day [1.0 mgd] capacity.

## Table 38. GRANBY SANITATION DISTRICT AND VAL MORITZ SHARE OF PROJECTED POPULATION SERVED

| Basis of projection | Projected population | | | | | | |
|---|---|---|---|---|---|---|---|
| | 1975 | 1980 | | 1985 | | 1990 | |
| | number | number | % | number | % | number | % |
| Val Moritz, base | | | | | | | |
| Granby Sanitation District | | | | | | | |
| Local | 1,200 | 1,420 | 60 | 1,580 | 28 | 1,760 | 18 |
| Val Moritz-induced | 0 | 60 | 2 | 380 | 7 | 760 | 8 |
| Total | 1,200 | 1,480 | 62 | 1,960 | 35 | 2,520 | 26 |
| Val Moritz | 0 | 900 | 38 | 3,600 | 65 | 7,200 | 74 |
| Total | 1,200 | 2,380 | 100 | 5,560 | 100 | 9,720 | 100 |
| Val Moritz, reduced | | | | | | | |
| Granby Sanitation District | | | | | | | |
| Local | 1,200 | 1,420 | 69 | 1,580 | 37 | 1,760 | 25 |
| Val Moritz-induced | 0 | 40 | 2 | 300 | 7 | 580 | 8 |
| Total | 1,200 | 1,460 | 71 | 1,880 | 44 | 2,340 | 33 |
| Val Moritz | 0 | 600 | 29 | 2,440 | 56 | 4,800 | 67 |
| Total | 1,200 | 2,060 | 100 | 4,280 | 100 | 7,140 | 100 |

### Table 39. ANNUAL CASH REQUIREMENTS FOR GRANBY SANITATION DISTRICT FOR PHASED AND UNPHASED PROJECTS

| Cost component | 1976-1980 | 1981-1985 | 1986-1990 |
|---|---|---|---|
| Unphased construction | | | |
| Capacity | Full[a] | Full[a] | Full[a] |
| Debt service (land + 30%) | $ 19,740 | 19,740 | 19,740 |
| Operations, maintenance and sinking fund | | | |
| No Val Moritz | $ 75,000 | 75,000 | 75,000 |
| Val Moritz base | $ 60,750 | 36,380 | 22,880 |
| Val Moritz reduced | $ 64,130 | 43,130 | 28,880 |
| Total cost to district | | | |
| No Val Moritz | $ 94,740 | 94,740 | 94,740 |
| Val Moritz base | $ 80,490 | 56,120 | 42,620 |
| Val Moritz reduced | $ 83,870 | 62,870 | 48,620 |
| Phased construction with Val Moritz | | | |
| Capacity | Phase 1[b] | Phase 1[b] | Phase 2[c] |
| Debt service (land +30%) | $ 11,920 | 11,920 | 11,980 |
| Operations, maintenance and sinking fund | | | |
| Base projections | $ 41,550 | 24,880 | 18,700 |
| Reduced projections | $ 43,860 | 29,500 | 23,600 |
| Total cost to district | | | |
| Base projections | $ 53,470 | 36,800 | 38,680 |
| Reduced projections | $ 55,780 | 41,420 | 43,580 |
| Phased construction without Val Moritz | | | |
| Capacity | Phase 1[b] | Phase 1[b] | Phase 1[b] |
| Debt service (100%) | $ 31,120 | 31,120 | 31,120 |
| Operations, maintenance and sinking fund (100%) | $ 47,000 | 47,000 | 47,000 |
| Total cost to district | $ 88,120 | 88,120 | 88,120 |

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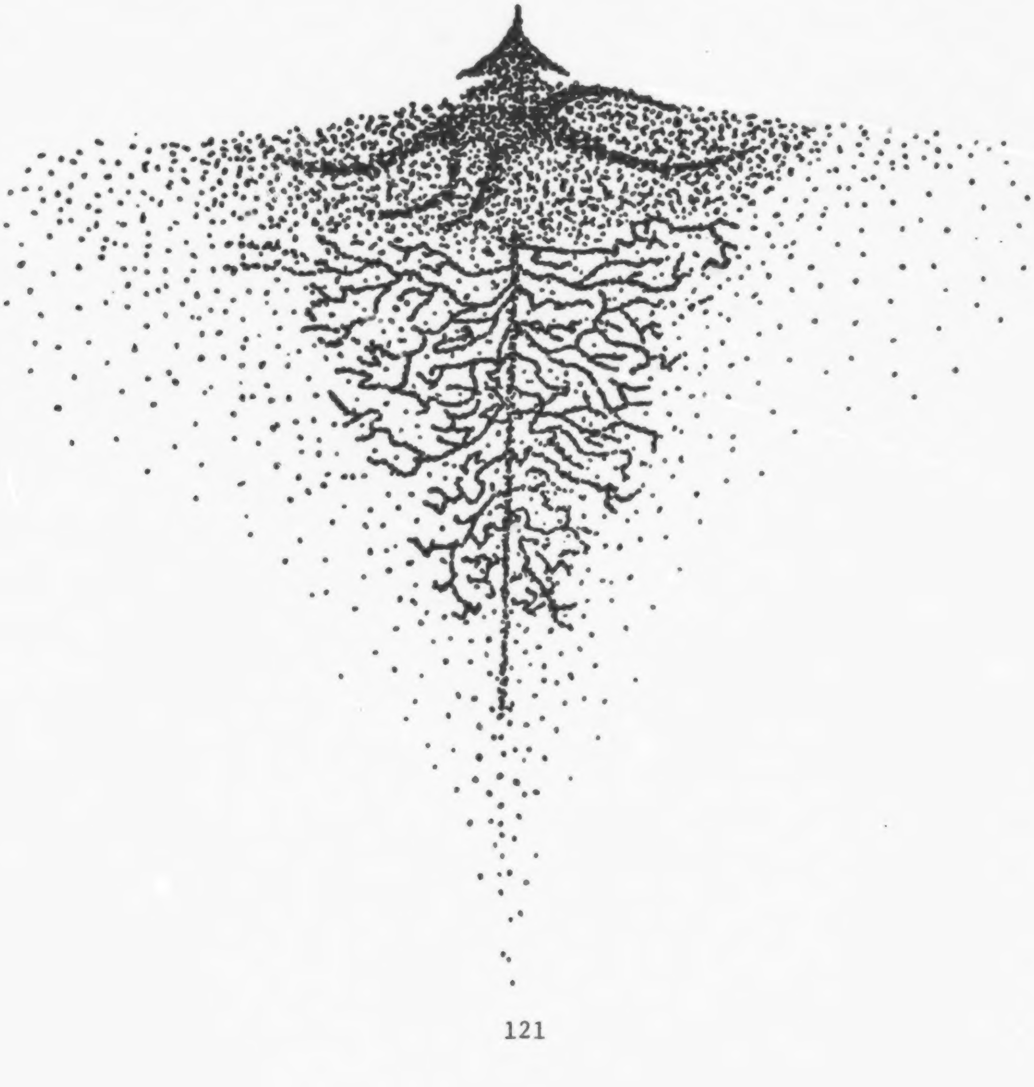
[a] Full capacity is 5700 cu m/day [1.5 mgd].

[b] Phase 1 capacity is 1900 cu m/day [0.5 mgd].

[c] Phase 2 capacity is 3800 cu m/day [1.0 mgd].

Analyzing phased construction without any development by Val Moritz implies a significantly higher cost for Granby as shown at the bottom of Table 39. These costs, which are assumed for the most part to be fixed, would be $88,000 per year over the full time period. The reason for the higher costs is that there would be no sharing of the costs, and consequently debt service costs to Granby would be significantly higher even for a smaller facility, while at the same time operating and maintenance costs would be fully absorbed throughout the fifteen-year planning period by Granby.

It should be noted in conclusion that the high cost of a 1900 cu m/day [0.5 mgd] plant to the Granby Sanitation District may conceivably preclude construction of even this small a facility if no successful agreement is reached between Val Moritz and the District.



# SECTION V

## ENVIRONMENTAL IMPACT OF THE PROPOSED ACTION

The facilities involved in the proposed action will have both beneficial and adverse impacts upon the natural environment as well as on institutions, economy and energy-utilization rates. These impacts were computed, assessed and/or estimated on the basis of available scientific knowledge, professional experience of the environmental team and experience of professionals in the local entities as well as the familiarity with local natural, social and economic conditions gained by the project team during the course of the conduct of the project.

The proposed action would be selected from the six distinct schemes described in Section IV, each embodying a train of feasible processes. Impacts of each alternative upon the environment are presented in order to provide an environmental evaluation of the widest selection of feasible courses of action. These impacts are presented under four main topics: (1) construction effects--those expected to occur only during the periods of excavation, pipe laying, construction and related temporary activities; (2) operation effects--those expected during the long-term, day-to-day operation of the proposed facilities, including those arising from financial burdens of the various possible alternatives; (3) growth-inducing impacts; and (4) secondary impacts--those arising from the growth induced by the facilities in their potential service area. Under each topic the impacts of the various alternatives are discussed in quantitative and qualitative terms, as appropriate.

### CONSTRUCTION EFFECTS

Alternative 1 involves no construction. Hence, comments in the following paragraphs pertain only to alternatives 2 through 6.

### Soils

All alternatives considered will have a minor destructive impact upon soil properties at the construction site, along pipeline routes and (particularly in alternatives 4 and 5) within the effluent storage ponds. Even though large areas of soil will be inundated by the storage ponds needed in alternatives 4 and 5, the low natural productivity of these soils for agriculture (capability ratings of VI and VII) makes the impact rather minor. Eventual reclamation of soils at the proposed sites will be possible with relatively little effort.

## Land Forms

Construction of large storage ponds, in alternatives 4 and 5, will substantially alter natural land forms over areas of 24 to 32 hectares [60 to 80 acres] from the present rolling drylands to permanent ponds.

## Water

Impacts upon surface water quality during the construction period are largely determined by the erosion potential at the treatment plant site and along pipeline routes and by precautions taken against erosion and measures employed to reduce its potential. All alternatives present essentially the same erosion problem; only the location of the sediment discharge will change from one treatment plant site to another. It is assumed though actual enforcement is dependent on local authorities that appropriate erosion control procedures, such as settling basins and hydromulching of slopes, will be taken to mitigate impacts. Water quality impacts would be short term in nature, and deposited sediment would probably be flushed away with the next spring runoff.

There will be virtually no impacts upon groundwater quality during the construction period.

## Vegetation and Habitats

### Alternative 2--

Construction of a sewage treatment plant in Alternative 2 would involve the removal of some riparian vegetation. Because of the proximity of this site to Highway 40, visual quality would be impaired by excessive removal of vegetation, particularly the willow trees and willow shrubs. Excessive vegetation removal would also increase erosion and would adversely affect water quality and aquatic habitat. Turbidity and sedimentation effects on the aquatic environment would be a short-term adverse effect. Physical stream conditions would be restored by the natural scouring effects of the spring flows.

### Alternative 3--

In Alternative 3, the treatment plant site is situated in a sagebrush community with low soil moisture. Vegetation removal may result in some localized soil erosion. Revegetation of the site may be rather slow without additional seeding and irrigation. The treatment plant would be visually exposed on the open hillside due to the absence of natural vegetation screens. However, its location in a remote and unpopulated area (Figure 10, Section III) largely mitigates this impact.

### Alternative 4--

The construction impacts of Alternative 4 are not confined to the land disposal site alone but include the length of the 9.1-km [5.8-mile] pipeline route as well. Pipeline construction would cause short-term disruption in linear segments of primarily the Sagebrush vegetation unit. The Fraser River crossing would temporarily increase stream turbidity and lead to increased sedimentation downstream. The effect on aquatic habitat would be short term. Physical stream conditions would be restored by the natural scouring effects of the spring flows. The smaller stream crossings--Rockwell, Muller and Eightmile creeks--would have a short-term, minor impact if construction occurred during the minimum-flow summer months. The pipeline route will have a negligible effect on roads as all crossings are through small, unpaved auxiliary roads.

The removal of 24 to 32 hectares [60 to 80 acres] of sagebrush and grassland for the stabilization ponds will have a permanent site-specific effect on vegetation and represent an irreparable loss of wildlife habitat. The removal of some lodgepole pines will also be unavoidable.

### Alternative 5--

The construction impacts of Alternative 5 will be mainly in the Grassland-Agriculture unit of the Granby Mesa area. Pipeline construction may cause minor land erosion and downstream sedimentation in Smith Creek and in the drainage ditches. The pasture and rangeland activities will be temporarily disrupted during construction also.

The removal of 24 to 32 hectares [60 to 80 acres] of grassland and sagebrush for the stabilization ponds will have a permanent site-specific effect on vegetation and represent an irreparable loss of wildlife habitat. The Granby Mesa rangelands are fairly extensive, and the stabilization pond site would actually consume a very small percentage of the total habitat.

### Alternative 6--

The initial construction impacts would probably be equal to those of Alternative 2. In successive years, as further construction is needed, impacts would be negligible. Plant enlargement would be within the confines of the developed site and should have much less impact than the original construction.

## Wildlife Patterns

### Alternatives 2 and 6--

During and immediately after construction, the aquatic environment may receive increased sedimentation and become more turbid. The sedimentation may temporarily affect aquatic inhabitants, particularly benthic invertebrates, which serve as food supply for fishes. Fish species abundance may decline slightly during this period but would return to normal within two seasons. Aquatic vegetation should return quickly after the construction season.

Terrestrial wildlife on the site consists primarily of several species of swallow and the black-billed magpie. These species would be displaced during construction to other nearby areas.

Alternative 3--

Stream impacts would be negligible compared to Alternative 2. Minor wildlife disturbance would also occur during construction. The treatment plant site itself occupies only a small area and thus would not cause significant impacts on wildlife.

Alternative 4--

Stream impacts, primarily for the Fraser River crossing, would be similar to those of Alternative 2. Pipeline construction would have short-term adverse effects on the sagebrush inhabitants, particularly ground squirrels. Construction of the stabilization ponds, however, represents a permanent change in local habitat. The effect will be particularly noticeable since the ponds bordering the forest will eliminate the existing forest-sagebrush "edge" habitat. Animal species intolerant to human presence would probably migrate to adjacent areas. If the adjacent areas are already stocked to capacity, the migrations will result in ultimate reduction in animal populations.

Alternative 5--

Stream impacts would be relatively minimal for this alternative. Pipeline construction would have short-term adverse effects on the grassland and sagebrush inhabitants. Construction of stabilization ponds would have less impact than in Alternative 4 as the local habitat is primarily grassland without any distinct "edge" environments. The upper mesa area, however, does serve as critical elk winter range. If construction is completed prior to the winter season, elk patterns should not be affected.

Air Quality

It is expected that alternatives 2, 3 and 6 will have a noticeable impact upon air quality during construction of the treatment plant and pipelines. Dust raised during site preparation and engine emissions from the construction equipment--largely devoid of air pollution emission controls--comprise the sources of air pollution during a maximum period of about three months. In alternatives 4 and 5, additional air pollution contributions can be expected from the construction of the long conveyance pipelines as well as from the excavation of effluent storage reservoirs. These activities will not have a severe or long-lasting impact upon local air quality. The remoteness of the treatment plant site (Site 5) under Alternative 3 and of the storage reservoir under alternatives 4 and 5 make air pollution under these alternatives even less noticeable to the residents of Granby.

Noise

Construction activities under all alternatives will increase background ambient noise levels in areas in the vicinity of the selected sites for a short period of time. On some occasions (such as pile driving for foundation preparation), heavy equipment will produce louder noise, audible at greater distances from the site. In alternatives where construction sites are removed from human habitation, noise at these levels will not be felt by local residents. Under alternatives 2, 3 and 6, however, a significant degree of annoyance will be experienced in the eastern parts of Granby.

Traffic and Circulation

Alternatives 2 through 5 will increase traffic volume by 100 automobile trips per day on Route 40, assuming a peak work force of 50. Alternative 6 will increase traffic by about 30 to 50 automobile trips per day.

Alternatives 2, 4, 5 and 6 will cause minor impacts on circulation as the construction sites are away from roads used by the public. In Alternative 3, the plant site is adjacent to Route 125, which has relatively narrow shoulders. Some disruption of traffic flow could occur if specific off-road parking areas, reserved for construction workers, are not provided on the site. Additional disruption in flow could occur during delivery of materials and equipment to the site. This can be reduced by providing the necessary access and turn-around space on the site.

Employment

Alternatives 2, 3, 4 and 5 will require employment of up to 50 construction-related workers. The local construction labor force is not adequate to meet this need. It may be necessary to import up to half the needed work force if local construction remains at its present moderate to active level; if a significant decline in other construction occurs, the need for imported labor will decline.

Alternative 6 may require less imported labor for the first phase. The impacts of the next two phases will also be small, although in future years the necessity for imported contruction labor will depend substantially on the state of the economy: should a significant amount of construction be underway at Val Moritz, or at any other project of significant size, it would be necessary to import the additional labor needed for these phases, although the number probably will not exceed 20 to 30 workers.

## OPERATIONAL IMPACTS

### Local Climate

Under alternatives 1, 2, 3 and 6 no change in climate is anticipated to occur. The microclimate in the spray areas of alternatives 4 and 5 will experience an appreciable increase in atmospheric humidity and a minor change in temperature variation (i.e., diurnal temperature range will probably be somewhat attenuated). This change will have no long-lasting impacts upon the environment and will disappear soon after spray operation is suspended. The higher humidity will encourage the growth of more lush vegetation in and about the irrigation and/or land disposal sites.

### Soils

No significant impact on soil conditions should result from alternatives 1, 2, 3 or 6. Alternatives 4 and 5 will have long-term effects, similar for the two alternatives. The storage ponds will cause gradual clogging of soil pores and reduction in soil permeability at the pond sites if the ponds are unlined. This change can be viewed as a beneficial impact from the point of view of conserving the water resource for irrigation (in Alternative 5) and in protecting groundwater supplies. However, the soil structure will be deteriorated and may require special amendments and cultural practices for reclamation in the future.

The spray sites will experience a gradual increase in soil organic matter content over several years, a distinctly beneficial impact. The nutrients in wastewater effluent will enrich soil productivity, and the heavy metals (though no special studies have been done, similar situations indicate that these would be low in Granby wastewaters) will have a rather minor negative impact over an extended period (more than 20 years) of application.

### Water

#### Quantities--

The impacts of proposed wastewater management alternatives upon water quantity in the Fraser and Colorado rivers will be limited. The present discharge of less than 0.014 cu m/sec [0.5 cfs] to the Fraser River is below five percent of the total flow in the Fraser River during the 10-year, 7-day low-flow period and is less than two percent of the flow of the Colorado River at its confluence with the Fraser River.

Diversion of this flow under the land disposal/application alternatives (4 or 5) would therefore have a limited or negligible effect on water quantity (though it might have significant legal implications, discussed below). The lower than average stream flow resulting from these alternatives would reduce aquatic productivity to a certain degree. An ultimate discharge of 5,700 cu m/day [1.5 mgd] to the Fraser River would constitute 20 percent of the low flow in the Fraser River and seven percent of the low flow in the Colorado River.

The impacts of the proposed alternatives on groundwater quantity are related to the location of the collection and interceptor sewers. Where sewers pass through areas of high groundwater, the groundwater flow paths may be bisected, causing a lower groundwater table in some areas and infiltration into the sewers. However, a high groundwater is not necessarily a desirable factor unless the groundwater is being used for water supply, which is no longer the case in the Granby area.

Legal implications. If a land application alternative (4 or 5) is adopted, removal of the sewage effluent discharges from the Fraser River would pose a legal problem for the Town of Granby (a distinct legal entity, separate from the Granby Sanitation District). This is due to the fact that the Town of Granby has acquired legally adjudicated appropriative rights to one cycle of use, of an established volume, of the Fraser River and groundwaters through historical withdrawals and (significantly) prompt returns of the treated sewage downstream to the river at or near an identified discharge point. The returned sewage, under the existing system of appropriations, belongs to senior consumptive users downstream, who would probably object to a cessation or reduction of the direct discharge. It is probable that a decision on the part of the Town of Granby to stop sewage effluent discharge to the Fraser River would lead to legal disputes unless the Town of Granby also decided to purchase adequate water rights from senior appropriators downstream and obtain the required judicial decrees. These procedures involve considerable expenditure of time and resources for engineering and legal research and reporting efforts as well as court costs and the purchase price for the rights to be acquired.

Quality--

Impacts on surface and groundwater quality will vary among the alternatives. Present discharges under Alternative 1 (no action) meet most water quality standards. It is apparent, however, that even if the flow rate does not increase appreciably the existing, unmodified facility will not be able to meet future discharge permit conditions which reflect both State and Federal requirements and Basin Plan recommendations with respect to ammonia and residual chlorine effluent limitations and total suspended solids and biochemical oxygen demand percent removals.

Alternative 2 was designed to meet the water quality standards with a greatly increased wastewater flow rate. Biochemical oxygen demand loading and nutrient loading to the Fraser River will increase but, because of high reaeration, will not significantly deplete the dissolved oxygen. The increased load will not cause algae growth. The total amount of ammonia discharged from the ultimate flow after ammonia removal will need to be less than that being discharged by the present Granby treatment plant. Alternative 3 will be superior to Alternative 2 from a water quality viewpoint because the effluent will be discharged to the Colorado River, where the higher flows will enhance dilution. Alternative 3 will also meet the existing water quality standards.

Alternative 4, involving land disposal, will have a beneficial effect on surface water quality by altogether removing the wasteloads from the stream. This will benefit downstream communities by removing the incremental salinity otherwise contributed by the discharges. Although there are no potable water wells in the vicinity of the disposal site, groundwater quality may be adversely affected. Particular problems may result from the buildup of nitrates in the groundwater, depending on the extent of removal accomplished by growing plants and by dilution.

Alternative 5 will have no adverse effects on groundwater or on surface water provided application rates are balanced with evapotranspiration by the crops.

Alternative 6 is a staged development plan and, with the exception of possibly smaller sewage flow (due to fewer growth-inducing effects), the water quality impacts will be similar to those of Alternative 2. An important advantage of Alternative 6 is the benefit of testing the operation of the facility and its ability to nitrify the effluent under cold-water conditions without investing in a larger facility that may not be capable of meeting the permit conditions.

## Biotic Communities

### Alternative 1--

The continued use of the existing facility and stream discharge would have long-term effects on the Fraser River aquatic community and would have several indirect impacts in the planning area as a whole.

In the past, the Granby wastewater treatment plant had difficulty meeting State standards for color, turbidity and biochemical oxygen demand in the effluent stream. The Colorado River Basin Water Quality Management Plan has identified high ammonia-nitrogen concentrations as a serious threat to the Fraser and Colorado Rivers. On the basis of preliminary model studies (Reference 2), continuation of the present level of treatment and discharge at Granby could lead to potential toxic summer concentrations of ammonia-nitrogen in the Fraser River. The high ammonia concentrations could lead to summer fish kills and overall reduction in benthic productivity. The nitrogen contribution would also have a seasonal stimulatory effect upon algal growth.

Without expansion of the Granby treatment plant, possible future developments, such as the proposed Val Moritz development, may be compelled to provide their own wastewater treatment facility. Additional impacts resulting from the building of another treatment plant would be keyed to the treatment level and the site characteristics. The effect of these impacts would be difficult to estimate at the present time.

Alternatives 2, 3 and 6--

The new treatment plant, at peak capacity, would discharge up to 5,700 cu m/day [1.5 mgd] of treated effluent into the Fraser and Colorado rivers. The upgraded effluent would improve aquatic habitat quality in comparison to Alternative 1. The volume of effluent discharged would almost triple the present level. Concomitant with this discharge would be an overall increase in total stream load. While concentrations of stream pollutants will be regulated to tolerable nontoxic levels, the overall aquatic environment would be gradually altered. Sensitive aquatic species may undergo population shifts. This effect is difficult to quantify because of the long-term gradual increase of the discharge.

Alternative 4--

The land disposal alternative eliminates wastewater discharge into the Fraser River. This would reduce the pollutant input to the aquatic system. However, cessation of stream recharge downstream from the municipal water intake would lead to a lower than average net stream flow. In this alternative, while overall stream quality would improve, aquatic habitat and productivity would be reduced.

Seven operational impacts upon the biotic community have been identified with the forest irrigation alternative:

1. Nitrates may build up in soils and vegetation from annual irrigation of the lodgepole pine ecosystem, over very long periods of time. This is due to the fact that little if any plant material is removed from the forest ecosystem.

2. Changes will occur in the successional status of the forest due to increased soil moisture. Such changes could favor the growth of more water-tolerant plant species along with lodgepole pine, which is capable of growing in moist conditions.

3. Passing migrant waterfowl will be attracted to additional water areas created by the aerated waste stabilization ponds.

4. Elk and deer winter areas and fall migrations will be disturbed as a result of construction and operational activities. Site 2 is near the Strawberry Creek area, which is an important elk and deer range. Deer may be slightly more disrupted, as their migrations begin in the early fall, while elk generally remain in the high country until the first snowfall.

5. Excess runoff may occur in certain areas. Erosion may be increased due to lack of the significant understory that is characteristic of lodgepole pine forests. Site 2 is near three watercourses which could receive effluent and sediment in runoff.

6. Wildlife patterns will be disrupted by changes in plant growth. Many smaller animals will be unable to adjust to the wet conditions during spraying. Some animal emigration and shift in species composition is expected.

7. If spraying is conducted over a longer period of time (i.e., fall and winter), pipeline freezing, ice formation and tree breakage may be additional problems.

Alternative 5--

Use of wastewater to irrigate croplands diverts a source of stream recharge, as discussed under Alternative 4, above. The Fraser River is subject to a minimum stream flow, required by SB 97 (Reference 109). The minimum flow is determined by the Colorado Division of Game, Fish and Parks for all State rivers. One of the primary goals of this legislation is to maintain a suitable amount of habitat for the sustenance and reproduction of aquatic species. Complete diversion of wastewater thus may have environmental ramifications (a certain loss of stream productivity and habitat) as well as serious legal implications, discussed above under Water Impacts.

The following operational impacts upon the biotic community are expected as a consequence of the crop irrigation alternative:

1. Stream and/or groundwater may be polluted--especially from nitrates--particularly where soils are underlain by a shallow groundwater table. The extent of pollution of the stream would be far less than that with direct discharges.

2. Heavy metals, bacteria and viruses from effluent can enter the ecosystem and food chain. This impact is not expected to be of significant proportions in Granby, as discussed in Appendix E.

3. From 24 to 32 hectares [60 to 80 acres] of land for stabilization ponds will be permanently removed from the natural environment.

4. The possibility exists of harm to plant growth from excess hydraulic loadings or poor soil aeration, or a combination of the two, if

the sprinkler system is not adequately operated and maintained.

5. Dispersion of spray-irrigated effluents into the neighboring areas by westerly winds moving through Windy Gap is a possibility which should be taken into account in design and operation of the system.

6. A beneficial increase in agricultural productivity will accrue from nutrients provided in wastewater. This could be maximized by proper crop selection.

7. It will be possible to expand agricultural activities, as a result of increased productivity and available water supply, in areas not presently utilized.

8. If irrigation systems are conducted such that they pose barriers to elk movement, this alternative will have a negative impact on their critical winter range. However, since most irrigation will be conducted in seasons other than winter, the impact will be minimal.

### Noise

None of the alternatives is expected to produce noise at levels significant to environmental concern. Air compressors and blowers are the only units that produce some noise, but these machines are usually equipped with silencers (snubbers or air compressors) to bring the noise levels below OSHA requirements (90 dBA).

### Odor

#### Alternative 1--

The existing plant emits unpleasant odors typical of sewage treatment plants, noticeable at distances of about 100 m [300 ft] from the plant. However, the plant is located in a site remote enough that these odors do not reach places of human residence and/or commercial activity. Even driving along the dirt road leading to and passing by the plant, one does not usually detect odors from the plant. The treatment plant is being operated very efficiently at the present time; hence the relatively low level of odor.

#### Alternatives 2, 3, 4, 5 and 6--

Unless mitigative measures (enumerated in Section VI) are incorporated into the design of the treatment processes, any treatment plant will emit the following: (1) septic odors from the influent pump station wet well and primary clarifiers; (2) characteristic odors from Biodisc or activated sludge units; (3) sulfur odors from anaerobic sludge digestor gases; and (4) odors generated in the sludge drying beds. As inflow into the plant increases, the severity of, and resultant annoyance from, the bad odors will increase. Due to the remoteness of the plant site in Alternative 3, the potential for its odors to reach annoyance proportions in Granby will be less than under the other alternatives.

In alternatives 4 and 5, where stabilization ponds and large storage areas for the effluent are necessary, odors may develop in the ponds. These odors would be due to the biological processes occurring in any free body of water with biostimulants (nitrogen, phosphorus, sunlight) in abundant quantities. Thus, nuisance conditions may be expected, especially if ponds are allowed to become anaerobic. This condition will occur in wintertime when ponds are covered with ice. The spring thaw usually involves a few days of severe odor problem.

## Air Quality

Wastewater treatment processes contemplated in the various alternatives generally do not contribute to air pollution. Small quantities of sulfides may be emitted from burning waste digestor gases, if such burning is included in the design. Miniscule quantities of ozone will be generated by electric motors in the plant. No carbon monoxide will be generated by any of the processes.

Spraying effluent in crop irrigation or land disposal schemes (alternatives 4 and 5) will produce aerosols containing microorganisms and the dissolved solids present in the effluent. These aerosols can be carried by wind to areas downwind of the spray areas; this dispersal of aerosols can be particularly significant in the Granby Mesa, with its high elevation in comparison with surrounding areas and its exposure to fast winds from Windy Gap. These considerations are utilized in the evaluation of alternative sites for land disposal and crop irrigation.

## Municipal Service Costs

As of January 1976, no cost sharing agreement existed between Val Moritz and the Granby Sanitation District regarding a new treatment facility. Assuming that sharing of operating and maintenance costs will be based in some manner on the actual use by Val Moritz residents, and that the growth of Val Moritz will be materially less certain than the costs to be incurred, the annual costs associated with the alternative systems were compared on the assumption that Granby would bear the full operating costs. This theoretical analysis indicated average costs to the District assuming full capacity for alternatives 2 through 5 and phased construction in alternative 6, as shown below:

| Alternative | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|
| Annual cost to District | $99,700 | 136,200 | 101,400 | 122,000 | 82,400 (average) |

Compared to current revenues, adjusted for the fee changes scheduled for 1976, all five alternatives show significant deficits which, in the absence of growth in revenues, would have to be met by increases in user fees, tap fees, tax rates, or a combination. These potential deficits would be offset to some degree by endogenous growth without Val Moritz. Even with such growth, there would still be substantial deficits for alternatives 2 through 5 without the additional revenue benefits of the direct and indirect growth generated by Val Moritz. Alternative 6 would, even if built on schedule to full capacity, produce a small surplus under these theoretical assumptions. The theoretical deficits without Val Moritz are shown below:

| Alternative | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|
| Deficit | -$12,400 | -49,100 | -14,200 | -34,900 | +4,700 (average) |

Even if Val Moritz develops at the lowest level projected in this report, there would appear to be adequate revenue to support the District costs under all alternatives by approximately 1985. Alternative 6, by virtue of its much smaller size, would not create any deficit initially if Val Moritz paid 70 percent of the capital costs but none of the operating costs, while alternative 2, the least costly of the four 5,700 cu m/day [1.5 mgd] alternatives would be fully funded by perhaps 1980 if Val Moritz grew as projected in the base projection.

## Property Tax Revenues

No significant amounts of taxable land will be removed from the tax rolls as a result of the proposed project.

Alternative 1 will have no effect. Alternatives 2, 3 and 6 would occupy the present site and/or a small amount of additional undeveloped land. Alternative 4 would necessitate utilization of portions of the National Forest, which is not on the local tax rolls. Alternative 5 would remove 24 to 32 hectares [40 to 60 acres] of agricultural land from the tax rolls.

## Employment Potential

Alternative 1 will not create new jobs. Alternatives 2 through 6 would create one or two jobs, with negligible effect on the local labor market.

Employment resulting from growth at Val Moritz and elsewhere in the service area of the proposed project cannot be determined at this time, though it could be substantial if Val Moritz successfully resumes sales.

## Property Values

Alternative 1 may have a depressing effect on property values to the extent that it might inhibit future development. Alternatives 2 through 6 anticipate the development of Val Moritz. If this occurs, property values in Granby may rise in response. If Val Moritz does not develop, property values will not rise, in the absence of other, yet undetermined, growth pressures.

## Public Health

Alternative 1 would not improve the quality of the present effluent discharge, which is occasionally substandard and is a source of contamination of local streams. The inadequate facilities for pit dumping and recreational vehicle waste disposal would not be improved, nor would a viable option for Moraine Park's existing sewage treatment problems be provided.

Alternatives 2 through 6 would all serve to resolve the existing problems by improving the quality of effluent discharge, providing pit dumping facilities and making possible a linkup with Moraine Park.

## Recreation

Alternative 1 will continue to endanger a valuable recreational resource by permitting continued discharge of occasionally substandard effluents into the Fraser River.

Alternatives 2 through 6 would correct the discharge problem and upgrade local river water quality and hence protect recreational use of the river. In addition, these alternatives would provide improved facilities for accepting wastes from campground toilets and from recreational vehicles, which are widely used in the area.

## Cultural and Aesthetic Impacts

There are no cultural impacts stemming from the proposed project. No known archaeological sites exist in the area, and historical land use for hunting suggests that no permanent Indian settlements ever existed here.

Alternative 1 will have no impact on the aesthetic character of the area. Alternatives 2 and 6 would have a slightly negative impact on local aesthetic qualities, though the preferred site, adjacent to the present facility, would cause little visual impact.

Alternative 4 could cause a significant negative aesthetic impact. Pipeline construction through range and forest land would substantially alter the appearance of the route for a period of years. The required access road to the waste stabilization ponds and the ponds themselves would seriously degrade the existing character of the land. Contrary to the Facilities Plan, there are no Ponderosa Pine stands in either of the land disposal sites. Hence, there would be no danger of their weakening or destruction.

Alternative 5 would affect the aesthetic qualities of the area less than alternative 4, but substantially more than alternatives 2 or 6. Some degradation of the aesthetic environment would result from the pipeline and pond construction. No National Forest land is required for this alternative.

Alternative 3 would place a sewage treatment plant along Highway 125. This is the least conspicuous of the five sites; nonetheless, this alternative would introduce construction where there is none at the present time.

## Utilities

Alternatives 2 through 6 would greatly expand sewerage service. No other public utilities would be significantly affected by the proposed project.

## Surface Water Resources

Alternative 1 will leave the existing occasionally substandard effluent discharge unimproved. This constitutes a potentially serious negative impact on the Fraser River.

The remaining alternatives will all have a beneficial impact on this resource.

## Underground Water Resources

None of the proposed alternatives is expected to have a significant impact on underground water resources. Alternatives 1, 2, 3 and 6 would discharge effluent directly to surface waters. Alternatives 4 and 5 would spray treated effluent on land. In both cases, it is expected that active uptake of nutrients by plants, adsorption on soil particles and mechanical filtration would substantially reduce encroachment of pollutants to groundwater reservoirs. If the storage ponds under alternative 4 or 5 were unlined, however, there could be an impact on the groundwater in the area.

## Traffic

The local highways (Highways 34, 40 and 125) have a design capacity far above current levels of use, as shown below.

| Current use (trips per day) | | Capacity (per day) |
|---|---|---|
| Route 34 | 2,550 | over 40,000 |
| Route 40 | 2,350 | over 40,000 |
| Route 125 | 380 | over 38,000 |

Projected increases in traffic by 1992, according to the State Department of Highways, will not bring total traffic to even 50 percent of design capacity on any of these highways.

## GROWTH INDUCING IMPACTS

Two classes of growth inducing impacts may be identified for any public project--direct impacts resulting from additional employment and/or local purchases by the project, and indirect or secondary effects.

For the proposed wastewater treatment facility the major question is whether or not there are any significant indirect effects and, if so, their magnitude and character. The direct growth inducing impacts are clearly minimal since the proposed project will only add two permanent jobs and local purchases of goods and services are expected to be minor and will represent only a negligible increase over present wastewater treatment operations.

### Relationship to Project Phasing

The secondary growth-inducing impacts of the proposed project may be affected by the phasing of construction. As discussed in the cost analysis section, there appears to be no economic justification for immediate construction of a 5700 cu m/day [1.5 mgd] facility at this time. A 1900 cu m/day [0.5 mgd] facility would appear to be adequate to meet all projected needs through the mid-1980's.

If the full 5700 cu m/day [1.5 mgd] facility were built, one effect would be to increase significantly, the pressures for additional growth in the service area. The substantially higher operating and debt service costs associated with development of a plant with at least 3800 cu m/day [1 mgd] initial excess capacity would create pressures on the District and its customers to encourage rapid expansion of the customer base as quickly as possible, to offset the adverse effects on user charges and taxes. This pressure could manifest itself in the encouragement of more rapid development at Val Moritz or the solicitation of additional second-home development in the area. Local residents could find it harder to maintain an independent and unbiased attitude toward additional growth in face of these additional municipal service costs.

Whether or not the proposed facility will have any significant indirect growth inducing impacts is, in turn, dependent on two other questions:

1. Are there local endogenous growth pressures which are now, or would foreseeably be, constrained by the absence of the proposed facility and the capacity it represents?
2. Are there potential additional exogenous sources of growth which would not materialize or would be significantly constrained if the project were not built?

## Local (Endogenous) Growth Factors

The town of Granby, which comprises almost all of the service area of the Granby Sanitation District, has a current population of approximately 1200 persons. Between 1960 and 1970, Granby's total population increased by about 50 persons. Since 1970, growth has been comparatively rapid, about 130 persons per year. The best available population projections suggest that future endogenous population growth will be greater than during the 1960-1970 period but somewhat less than the early 1970's. By 1990, population is projected to reach approximately 1,760 persons. This represents a long term growth rate of approximately thirty persons per year.

Wastewater treatment in the general Granby area is presently accomplished either through the present facilities of the Granby Sanitation District or, in areas outside its service boundaries, through the use of septic tanks, and the presently unsatisfactory Moraine Park facilities.

Although the existing wastewater treatment plant is nearing capacity, the present facility has a severe infiltration problem, accounting for perhaps 1140 cu m/day [0.3 mgd] during peak snow melt and irrigation seasons. The correction of this problem, which can be accomplished without the construction of a new treatment plant, or alternatively, the construction of only the first phase of the proposed project with a capacity of 1900 cu m/day [0.5 mgd] would provide adequate growth capacity for all anticipated local (endogenous) growth.

## Externally Caused (Exogenous) Growth Factors

There appear to be three potential sources of externally caused population growth in the Granby Sanitation District that may not have been fully considered in the state population projections: (1) the growth induced by the Climax Molybdenum mine nearing completion; (2) potential growth attributable to the attraction of light industry to the area; and (3) the potentially substantial growth inducing impacts of the large-scale development of Val Moritz as a second home-recreation area. It is not possible to determine to what extent these potential growth sources have been fully considered in the development of the State population projections for Grand County, which are, in turn, the basis for the projection of endogenous local growth. It seems reasonable to assume that these projections do envisage some continuing expansion of general tourism in the area. Given the substantially higher projections in the Water Quality Management Plan, it is unlikely that the State population projections fully account for the substantial impacts of Val Moritz.

With respect to the growth inducing effects of the Climax Molybdenum mine working population, it appears that most of this growth will be absorbed at communities closer to the site than Granby, although some effect may be felt in Granby.

Similarly, the recent acquisition of approximately 9.7 hectares [24 acres] of land near Granby by the town of Granby for the purpose of attracting light industry does not appear, in the short run, to be a major growth inducing factor. While the addition of a modest number of employees to the work force in Granby may have a beneficial effect on the local economy, it is quite uncertain whether such industrial development efforts will succeed and, if they succeed, the extent to which they would significantly modify the local population growth projections.

In summary, it would appear that except for Val Moritz, exogenous growth factors affecting the Granby Sanitation District service area are not likely to produce significant changes in projected local growth. Population increases of perhaps 100-300 over the next five or ten years might be reasonably attributed to such a factor, but they would not materially change the local population characteristics nor would they materially increase the need for wastewater treatment facilities.

The relationship of the proposed wastewater treatment project to Val Moritz is complex. Under current state law, and given the policies of the Grand County Board of Commissioners, it is highly unlikely that Val Moritz will develop to its projected size without additional wastewater treatment facilities. The logical source for such additional facilities would be the Granby Sanitation District and this has been, in fact, a major factor in the development of plans for the proposed project.

The negotiations between the Del Webb Corporation and the Granby Sanitation District as to cost sharing, sizing and the sharing of operating costs between the District and Val Moritz are still continuing. Their precise outcome cannot yet be determined nor can it be determined whether or not an agreement will be reached between the two parties.

The best available current indicators suggest that without the proposed project in one form or another, Val Moritz will not be able to complete its proposed development. Therefore, it appears that the growth-inducing impacts of Val Moritz are related to the proposed project.

Projections of the growth inducing impacts of the proposed project and the continued growth of Val Moritz can be found in both the Facilities Plan for the proposed project and in the Water Quality Management Plan (Reference 2). As noted previously, the projections for Val Moritz development contained in both these sources were predicated on the best available data in 1974, at which time Val Moritz had launched an apparently highly successful sales effort and looked forward to very rapid development. Since that time, sales and development efforts have been halted with no firm schedule for resumption, although it appears that they may resume in 1976. General economic conditions in the second-home market have deteriorated, and while there is some evidence of recovery, the extent of recovery and its timing are still quite uncertain.

In view of these factors, a new and independent set of growth projections has been prepared, and is presented here. The mechanisms and assumptions used in the projection of induced growth attributable to Val Moritz closely parallel those used in the Facilities Plan (Reference 1).

The key factor in such projections is necessarily an estimate of the cumulative sales rate and the cumulative build-out rate for Val Moritz. The sale of unimproved lots for second-home development is typically associated with very slow rates of buildup in most second-home developments. This is in part due to the fact that most such lots are purchased on seven to ten-year financing and many owners will postpone any development of second homes until such time as the lots have been paid for (Reference 60). On a national average, less than half of the lots (and often as low as 20 to 25 percent) are typically built in a subdivision after ten years of active and intensive sales. The situation is further complicated in Val Moritz insofar as the developers propose to sell both unimproved lots and condominiums. No firm estimates could be obtained from project personnel with respect to the sequence in which lots and condominiums will be built.

Given these uncertainties about Val Moritz, concerning the timing and extent of its resumption of sales and development, the mix of lots and condominiums, and the appropriate construction rates for the unimproved lots, any estimate of its development must necessarily be a preliminary (and to some extent arbitrary) projection.

Based on conversations with County planning personnel, and Val Moritz project personnel, it was possible to develop some preliminary estimates of the probable cumulative sales and cumulative construction rate over the next ten years (References 61, 112). It is estimated that approximately 4,000 units (including both lots and condominiums) will be sold by 1985, and at that time there will be approximately 1,200 completed dwelling units representing separate connections to the proposed sewer system.

The nature of recreation and second-home development is that it proceeds at a compounding rate, particularly with respect to building. As the development matures and as the recreational features promised by the developer materialize, the pace of actual home building intensifies.

To reflect the impact of the delay between lot sale and home construction, an interpolated estimate of sales and connections through 1980 was also made. In addition, projections of further development through 1990 were generated to cover the full 15-year analysis period. These estimates are presented in Table 40.

Table 40. BASE ESTIMATED CUMULATIVE SALES AND SEWER CONNECTIONS

| Year | Cumulative sales, units | Cumulative sewer connections |
|---|---|---|
| 1980 | 2,000 | 300 |
| 1985 | 4,000 | 1,200 |
| 1990 | 6,000 | 2,400 |

In addition to the foregoing "base projections" for Val Moritz development, an alternative set of projections representing deliberately more conservative estimates of sales rates is shown in Table 41. In this reduced projection, it was assumed that sales would be reduced by approximately one-third, but that the relationship between sales and actual development or sewer connections would remain approximately the same. The reduced projections are shown in Table 41.

Table 41. REDUCED ESTIMATED CUMULATIVE SALES AND SEWER CONNECTIONS

| Year | Cumulative sales, units | Cumulative sewer connections |
|---|---|---|
| 1980 | 1,300 | 200 |
| 1985 | 2,700 | 800 |
| 1990 | 4,000 | 1,400 |

On the basis of information gathered in various studies of tourism, tourist spending and employment elsewhere in Colorado, the Facilities Plan developed estimates of induced employment. These estimates were based on: (1) projected visitor spending in 1974 dollars; (2) application of sales-per-employee ratios to arrive at direct employment; (3) application of an employment multiplier to the direct employment estimate to obtain total employment; and (4) then estimating population from total induced employment. Table 42 presents a summary of the mechanics of this calculation and shows an induced population of approximately 60 persons by 1980, 400 persons by 1985 and 760 persons by 1990.

Table 42 shows that with the base projections for Val Moritz growth, the peak population of the town of Granby and Val Moritz will rise from

## Table 42. ESTIMATED EMPLOYMENT AND POPULATION GROWTH INDUCED BY THE PROPOSED PROJECT ASSUMING THE CONTINUED GROWTH OF VAL MORITZ

| Growth component | 1980 | 1985 | 1990 |
|---|---|---|---|
| Cumulative unit sales | 2,000 | 4,000 | 6,000 |
| Cumulative housing unit completions (connections) | 300 | 1,200 | 2,400 |
| Annual seasonal expenditures by second-home residents @ $200 per hh per week for 17 weeks per year | $1,020,000 | 4,080,000 | 8,160,000 |
| Direct employment (2nd homes) | 23 | 91 | 181 |
| Cumulative hotel units | 0 | 120 | 240 |
| Direct employment induced by hotel business (at .37 jobs per room: assuming 50 percent occupancy; 2 persons per room; $45/day/person; $45,000 per job) | 0 | 44 | 88 |
| Total direct employment | 23 | 135 | 269 |
| Total employment @ 1.7 times direct) | 39 | 230 | 457 |
| Total induced population (assuming employment/population = 60 percent) | 64 | 382 | 762 |
| Add: | | | |
| Val Moritz population (peak of 3 persons per housing unit) | 900 | 3,600 | 7,200 |
| Endogenous population (see Table 19) | 1,420 | 1,580 | 1,760 |
| Peak total population (rounded) | 2,380 | 5,560 | 9,720 |

the current level of 1,200 to approximately 9,700 by 1990. By 1990, the population in Granby itself will be approximately 2,510 while the seasonal peak population of Val Moritz will be approximately 7,200.

If instead the "reduced projections" are used, population would rise to only about 7,100 by 1990, of which 4,800 would represent the seasonal peak population of Val Moritz while 2,340 would be the estimated population of the town of Granby.

Therefore, to the extent that the full development of Val Moritz can reasonably be related or attributed to the completion of the wastewater treatment facility, the growth inducing effects attributable to the proposed project would be an increase of a peak population of approximately 8,000 persons over the next fifteen years under the base projection or approximately 5,400 persons using the reduced projections. Most of this effect would be felt in the ten-year period between 1980 and 1990, since the effects through 1980 would be relatively modest, due to the slow build-up anticipated for Val Moritz, both in terms of reduced employment and peak seasonal population at Val Moritz.

The total peak population derived in Table 42 consists of three components: (1) growth which will be induced by Val Moritz elsewhere in the Granby Sanitation District; (2) the seasonal population of Val Moritz; and (3) the endogenous population.

Growth that may be induced by the proposed project, or which may result from the removal of an obstacle to growth, will in its turn cause impacts of a secondary and tertiary nature. The development of Val Moritz, for example, would stimulate economic activity in Granby, generating population growth. This growth would, in turn, stimulate additional, though lesser, population growth. A larger population would affect the physical environment through increases in vehicle emissions, energy consumption, solid waste generation, etc. discussed in the following sections.

## SECONDARY IMPACTS

Secondary impacts of the proposed action are those resulting from new growth and development which is induced and/or made possible by the action. It is widely acknowledged that the *raison d'être* of the proposed action (provision of sewage treatment capacity beyond the present needs of the town of Granby and surrounding areas) is the development in the area southeast of Granby proposed by the Val Moritz Development Company.

The Colorado River Basin Water Quality Management Plan (Reference 2) adopted by the Colorado State Department of Health recommends joint facilities for wastewater management for Granby and Val Moritz. This recommendation makes the provision of separate treatment facilities for Val Moritz subject to specific approval by the Water Quality Control Commission of the State Department of Health. Therefore, at this time the very possibility of land development and population expansion in the southern part of the planning area in part depends upon the provision of new wastewater treatment facilities. Hence, even though wastewater facilities may not have a direct growth-inducement potential they are nonetheless essential for such growth. The potential future service area of such facilities therefore necessarily becomes the scene of the secondary impacts described below. In the following paragraphs the secondary impacts of alternatives 2 through 6 are discussed.

### Soils

Most of the soils in the planning area are readily erodible and severely limited insofar as their "community development" capability is concerned. This severe rating has been designated by the U.S. Soil Conservation Service (Reference 116) on the basis of depth to bedrock, slope, stones, caving of cutbanks (evident in some of the Val Moritz roadcuts), shrink-swell potential, low strength for supporting roadbeds and light structures, and other localized, specific problems. Placement of residential communities on such soils can produce intolerable quantities of erosion and sedimentation downstream in addition to the unsightliness of eroded areas. Potential slope failures and foundation problems may endanger life and property unless extensive borings and sophisticated foundation analyses are made and proper footings are provided, particularly for the larger structures such as multifamily dwellings, hotels and commercial areas.

### Water

All alternatives will have similar potential for secondary water quality impacts. Additional residential development in the Granby area will cause some pollution due to nonpoint sources of runoff. For example, if the streets in the speculated development areas are paved, the runoff from streets and other paved areas will contain pollutants. However, because of the seasonal nature of the development, this will occur to a lesser degree than is normally associated with year-round-occupancy residential areas. Erosion from unpaved areas and cut and filled slopes during construction of the development (until vegetation takes hold) will cause some sediment to be discharged into the streams; however, measures can be employed to reduce these effects. Generally then, secondary impacts upon water quality will be amenable to mitigation with proper design of the conveyance structures and treatment of runoff. It is very important that regulatory controls be established, implemented and rigorously enforced so that the necessary mitigative measures are actually designed and built into the developments that are permitted. The Areawide Water Quality Management Plan (sponsored by EPA) that is on-going for this area will address this issue and will offer a plan to accomplish these needs.

### Biotic Communities

#### Alternatives 2, 3, 4, 5 and 6--

The construction and operation of a wastewater treatment facility with immediate or ultimate capacity of 5,700 cu m/day [1.5 mgd] would make available a vitally important utility for future developments and subdivisions in the Granby area. Secondary effects resulting from the proposed action would be impacts associated with development and human habitation of valley areas and the potential for future subdivision of further open spaces in the planning area.

Mountain subdivision generally involves the division of large areas into small parcels, with open space and recreational sites being interspersed among clustered homesites. The planned Val Moritz development is such a subdivision. Expected general impacts to vegetation and wildlife resulting from this and other subdivisions are briefly described below.

1. Lands suitable for subdivision are frequently areas of agricultural potential with fertile, well-developed soils. Although they may not currently be under agricultural use, these areas are effectively removed from the agricultural land base by subdivision and development. The climate of the Granby area, however, is not favorable for highly productive agricultural activities. Thus, the major impact of subdivision involves the removal of land areas from the open spaces of this mountainous region.

2. Subdivision and development bring about a change in the visual and aesthetic quality of a mountain park region by the creation of buildings and structures in former open and undisturbed areas. The replacement of natural features by man-made structures causes a general decrease in visual and aesthetic quality

3. Soil erosion resulting from vegetation removal during road

construction, building site clearing and fire-control activities is a major short-term impact of subdivision. This impact is compounded in steeply sloping areas. Soil erosion may become a long-term effect in the highly erodible areas which are cut and left uncovered.

4. Loss of wildlife habitat because of the reduction of food and shelter available to wildlife as well as increased population density is a long-term secondary impact.

5. Increased population density causes an increase in the potential for accidental wildfires. In forested areas with a high fire potential, wildfires are difficult to control and can result in the destruction of human life and property as well as in the loss of vegetation and wildlife. On the other hand, increased population will result in higher priority being given to fire prevention and protection.

6. Sediments and fertilizer leachates can enter streams, particularly where housing sites are located near watercourses. Fertilizer and pesticide residues, such as nitrates and phosphates, provide a nutrient source for algae and can lead to stream pollution.

7. The Granby Mesa area and South-facing slopes are important wildlife wintering areas, as shown in Figure 12 (Section III). The future development of Val Moritz will have a significant impact on the critical deer and elk wintering range. The approved 635 lot subdivision of "Innsbruck" falls completely within general deer winter range. Approximately one-third of the building area would occupy the *critical* deer winter range near Tenmile Creek. The remaining Val Moritz property almost completely surrounds this critical deer area on BLM land, and encroaches upon the critical deer and elk areas near Strawberry Creek. The human occupation and disturbance of critical wintering areas may have a profound effect on wildlife.

> *Even if areas of critical winter range* [in the proposed Val Moritz area] *have been consumed, the absolute effect on a herd using that range is not well known. If 20 percent of the critical winter range for a deer herd is used by man, it is not clear that the herd will decrease by 20 percent The effect of the habitat loss may not become apparent until a particularly severe winter occurs. Even if the herd did decrease by 20 percent, we do not know if the animals have actually died or if they have selected a new habitat area that fulfills their requirements. However, it may be generally stated that as critical areas are consumed greater pressure may result in a lowering of forage quality in the suitable area. The lowered quality will then affect the entire herd, reducing the herd's visibility* [sic] *and survival potential during periods of increased stress.* (Reference 27)

8. Domestic animals such as dogs and cats roaming the area often

harass and/or kill livestock and wildlife. Many subdivisions have deed restrictions requiring that dogs be kept under control at all times. Such restrictions must be accompanied by determined enforcement to be successful.

9. Off-road vehicles, such as motorbikes, four-wheel-drive vehicles and snowmobiles, can cause destruction of vegetation, soil compaction, soil erosion, noise and disruption of wildlife habitat. Deed restrictions governing the use of off-road vehicles or setting aside specific areas for off-road vehicle use can be implemented to mitigate this impact. However, a general increase in developments and populations can be expected to lead to much increased use of these types of vehicles even though mitigation measures are undertaken.

## Other Secondary Impacts

There are other impacts associated with growth inducement potential of the wastewater treatment facilities. Secondary impacts on environmental parameters such as air quality, noise and odor can be quite significant. Use of fossil fuels in the periodic movement involved in second-home ownership and the inevitable change from a quiet, rural setting to a gradually more crowded urban life style are other secondary impacts which must be recognized.

# SECTION VI

## ADVERSE IMPACTS AND MITIGATIVE MEASURES

### SOILS

Erosion and loss of soil during the construction period, under alternatives 2 through 6, comprises the single most important impact on this parameter. Construction of residential facilities, made possible with the availability of sewerage service in the proposed development areas, will have an even greater erosion potential. Although the soils in the study area are not prime agricultural soils, they are nonetheless very important in supporting the natural vegetation. Furthermore, transport of eroded soils into the waterways leads to degradation of water quality in those streams. This impact can be extremely intensive and long lasting if it is not controlled. Therefore, mitigative measures must be incorporated during the construction period to prevent, or at least minimize, soil losses. Erosion control measures, enumerated below, are fully described in Reference 117.

Vegetative methods for erosion control include the use of perennial grasses and legumes; annual cover; trees, shrubs and vines; and mulches (organic and inorganic) to support vegetation and protect the soil. A recent method of erosion control is hydromulching and involves applying grass seed, wood fiber and water under pressure. Chemical mulching products are sometimes used temporarily, until vegetation grows strong enough to hold the soil. Chemicals used include polyvinyl alcohol, resins, elastomeric polymer emulsions, Curasol and Landlock. Structural erosion control and sediment entrapment measures include small flood-control dams, dikes and levees; stream channel improvements and bank stabilization works; sediment basins and outfall structures; terraces and diversion structures and channels; grassed waterways and outlets; and grade stabilizing structures such as chutes, checkdams and drop spillways. Serrated side slopes on highways have recently been employed with success to reduce erosion.

### LAND FORMS

The semi-permanent change from dry land to a lake is a drastic impact upon effluent storage areas and is viewed by some as adverse. However, the natural character of the area is such that water bodies do not present a highly atypical setting. Secondary impacts of the availability of sewerage service upon land forms are much more severe and adverse, producing a drastic change from a natural, unbroken mountain landscape to a semi-urban, residential and commercial setting.

## WATER

The primary justification for construction of wastewater treatment facilities is protection of surface and groundwater supplies against pollution. With adequate attention to design details, the proposed action will protect these water resources.

The mitigative measures against soil erosion can also be viewed as mitigative measures against water quality degradation from sediment transport from construction of the proposed sewerage facilities as well as future development areas made possible thereby. Thus, their implementation should be given high priority. As previously mentioned, the Areawide Water Quality Plan being conducted on the project area will directly address this issue.

Under alternatives 4 and 5, pollution of groundwater supplies is an adverse impact of land application of effluents. This impact can be mitigated in large part through proper design of application rates coordinated with actual and potential evapotranspiration and maintained below soil percolation rates.

## FLORA AND FAUNA

### Aquatic Toxicity

Under the no-action alternative 1, fish toxicity due to ammonia (especially during summer months) and residual chlorine can be expected to continue until future upgrading of the treatment plant is accomplished. Such upgrading would necessitate addition of a nitrification process and selection of a disinfection method which does not leave residual chlorine in the discharged effluent.

### Removal of Vegetation

Construction of the treatment plant and pipelines under alternatives 2, 3, 4, 5 and 6 will involve removal of natural and introduced vegetation from the construction sites. The population growth and land development which may become possible as a result of availability of additional increased sewerage capacity in the planning area would have an even greater destructive impact on local vegetation. Not only would removal of existing vegetation be an adverse impact, but the ensuing increased erodibility of the soils would further reduce aesthetic qualities of the utilized sites and degrade stream water quality with transported sediments and nutrients. This impact could be partially mitigated by careful retention of as much vegetation as practical and quick revegetation of denuded areas.

## Pollutant-Tolerant Species Selection

Stream discharge of wastewater effluent under alternatives 1, 2, 3 and 6 will contribute to the continued (and on-going) long-term selection effect favoring pollutant-tolerant aquatic species. Sensitive species may remain but will not compete successfully with the tolerant species. This impact can be mitigated only by a reduction of the pollutant load through selection of the most effective treatment processes and continuation of highly competent and reliable plant operation procedures and techniques.

## Short-Term Pipeline Crossing Construction Effects

Under alternatives 4 and 5, where pipelines would be laid across Fraser River, a temporary degradation of aquatic habitats would result from altered flow patterns, increased sediment loads and other physical changes in the river. These effects can be minimized if construction of the pipeline crossing is scheduled and implemented during the period of minimal aquatic biotic activity.

## Decreased Aquatic Habitat

Under alternatives 4 and 5, where land application would inhibit return of effluent to the stream immediately downstream of Granby, a reduced river flow of a fraction of one percent would be experienced during most periods. During low flow periods, the reduction could be more significant, leading to a slight decrease in aquatic habitat and productivity, particularly during the summer season.

## Moisture-Tolerant Species Selection

Seasonal forest irrigation with wastewater under alternative 5 would lead to a shift in the existing lodgepole pine understory. Moisture-tolerant plant and animal species would be particularly selected for by the irrigation process, causing a gradual shift in species composition and distribution. This effect would be reduced slightly by the limited spray-irrigation season, but is nevertheless unavoidable.

## Removal of Wildlife Wintering Areas

The 24 to 32 hectare [60 to 80 acre] stabilization ponds required under both alternatives 4 and 5 would permanently remove a portion of the wildlife wintering area. Conversion of the existing mixed grassland and sagebrush to monoculture would alter the winter forage supply. Fall harvesting would remove large amounts of potential hay forage as well. The effect upon wildlife would be difficult to ascertain quantitatively; however, a decrease in winter range would alter wildlife feeding patterns and could strongly affect the wildlife carrying capacity and total populations.

Although the habitat type would be altered, some agricultural techniques could be utilized to mitigate this impact to the benefit of wildlife. Residual and surplus areas, such as streambanks, road edges, fencerows, corners and woodland patches, when left uncultivated, provide important wildlife habitat (Reference 118). Unharvested strips, stubble and fallow areas would also provide an important supplement.

### Plant Growth Reduction

Harm to plant growth can result from excess hydraulic loadings or poor soil aeration under certain conditions under alternatives 4 and 5. Selection of the most suitable soils, the most tolerant crop species and the optimum irrigation practices should help control this effect.

## NOISE

The natural serenity of the mountainous setting of Granby can be threatened with noise produced especially during construction activities. Use of vibratory hammers instead of ordinary pile drivers, where practical, and silencers on compressors and other equipment can help to preserve the quietude of the area.

## ODORS

Even the most sophisticated wastewater treatment facilities can emit unpleasant odors if precautions are not taken. Some of the mitigative design features for odor control include (1) scrubbing air from the influent pump station wet-well by pumping it into the aeration basin in the activated sludge process or into exidizing baths; (2) provision of covers over primary clarifiers, drawing air from under the cover and scrubbing, as above; (3) provision of separate enclosures over the Biodisc units (if such units are used) with scrubbing or ventilation of the air space; (4) use of deodorizing mists downwind of the wastewater treatment plant during periods of particularly bad odor formation or during malfunctions. The latter method is particularly useful for controlling odors from anaerobic sludge digestors.

Odors formed in the stabilization ponds can also cause nuisance conditions which are harder to mitigate. It is the prolific algal blooms and their subsequent decomposition that lead to malodorous conditions in such lakes. Limitations of biostimulants, particularly phosphorus, from the effluent are not easy to accomplish. They involve addition of expensive tertiary treatment chemical units with high cost and commitment of large quantities of chemicals.

## AIR QUALITY

Dust control, with the use of dust palliatives, during the construction period can mitigate air pollution from this source. Emissions from construction equipment are adverse air pollution impacts which cannot be mitigated as long as pollution control equipment is not required on these machines by the regulatory agencies. Air quality degradation caused by the secondary impact of induced growth in the area can be considerable.

## RESOURCES

There are no significant adverse impacts on the natural or other resources associated with any of the alternatives. However, the secondary effects (caused by increased population growth in the area made possible and induced by the new treatment plant, particularly the larger version of alternatives 2 and 3) implicitly involve gradual loss or deterioration of the following resources:

(1) soils eroded from construction sites,
(2) wildlife habitats covered with residences and commercial activities,
(3) the aesthetic quality of the mountain areas marred by structures built for second-home residences and other activities,
(4) use of fossil fuels in the periodic movement involved in second-home ownership and
(5) quality of rural life gradually changing toward an urban condition with its concomitant problems.

## ECONOMY

A negative economic impact of the proposed project is its potentially serious effect on property tax rates and/or user charges resulting from slower-than-projected growth and associated decreased annual revenues. Alternatives involving a 5,700 cu m/day [1.5 mgd] plant presume and require large and rapid growth to avoid this impact because the service capacity and the cost of providing and maintaining it are immediate. Any growth induced by the wastewater treatment plant will also have significant economic impacts upon the town of Granby. Alternative 6, the staged expansion service capacity, will permit the increase in capacity and cost to be limited if service demand does not grow as rapidly as originally projected.

## AESTHETICS

The treatment plant would be visible from a distance which varies depending upon the finally selected site. Site 5 would be least visible (see Figure 10) and site 1 would be moderately visible, whereas sites 2, 3 and 4 would be relatively highly visible.

The visual and aesthetic environment will also be adversely affected by alternatives 4 and 5. The pipeline routes will show the effects of the trench excavation, which cannot be immediately mitigated. Post-construction restoration and quick revegetation can reduce the duration of the disturbance.

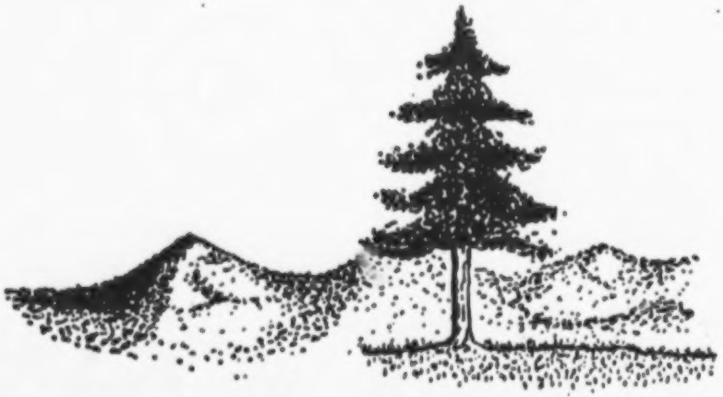
The roads leading to the ponds, and the ponds themselves, can more seriously affect the visual environment. If these alternatives are selected, careful siting is essential as a reasonable mitigating measure.

The growth and development which would be made possible with provision of reserve sewerage capacity under alternatives 2, 3, 4 and 5 could lead to highly reduced aesthetic quality of the area due to a drastic change from natural to urban setting.

## LAND USE

Alternatives 2, 3, 4 and 5 are sized beyond the district's present needs, on the assumption that the growth of Val Moritz would occur as originally projected by the developers. It is already evident that Val Moritz will not grow at that rate. Sales have been suspended since the fall of 1974 and as of January, 1976 have not been resumed.

Future growth of Val Moritz cannot be assumed. If it should not materialize, the revenues needed to meet capital and operating costs could create pressure to permit, or even encourage, development that might otherwise be considered undesirable. Land use planning and the willingness to grant exemptions to existing regulations could thus be influenced by the differing but substantial revenues made necessary by these alternatives.



# SECTION VII

# IRREVERSIBLE AND IRRETRIEVABLE RESOURCE COMMITMENTS

Two major commitments of resources have been identified with the implementation of a wastewater treatment facilities plan. The extent of resource commitments varies among the alternatives considered. These commitments are necessary elements of the wastewater treatment systems and, even with mitigative factors, are unavoidable. They are (1) loss of habitat and (2) commitment of energy and economic resources.

## IRRETRIEVABLE LOSS OF WILDLIFE HABITAT

Alteration and loss of wildlife habitat will be least for the construction of a secondary wastewater treatment plant (alternatives 2, 3 and 6) and greatest for the land application method (alternatives 4 and 5). Alternative 1 involves no construction beyond the existing treatment plant site and hence no further commitment of wildlife habitat.

Treatment plant siting adjacent to the Fraser River (alternatives 2 and 6) commits 4 to 8 hectares [10 to 20 acres] of riparian habitat to treatment facilities. Construction of the physical components such as tanks, basins and other structures permanently removes those areas from the natural environment. The Coyote Creek site (alternative 3) involves similar commitments on a portion of the sagebrush habitat.

The land application alternatives require a much greater commitment of wildlife habitat. The 24 to 32 hectares [60 to 80 acres] required for stabilization ponds permanently remove that area from the natural environment. The impacts of spray-irrigation of wastewater on vegetation are discussed in Section VI. Short-term vegetation changes are largely reversible. However, the long-term practice of wastewater irrigation could physically, as well as functionally, change the composition of the biotic community.

The secondary impacts of alternatives 2 through 6 involve growth inducement and its resultant human effects upon the environment. The actualization of the Val Moritz development would cause water quality degradation through erosion and sediment transport, a physical destruction of critical deer winter habitat and a functional deterioration of habitat due to barrier construction, excessive noise, dog and cat predation, vegetation changes and human presence.

## IRREVERSIBLE AND IRRETRIEVABLE ENERGY AND ECONOMIC RESOURCE COMMITMENT

While no alternative under consideration is a large user of energy, there are relative differences.

Alternative 4 will commit the Sanitation District to pumping sewage (10 to 11 km [6 to 7 miles]) to a higher elevation (210 m [700 ft]). Alternative 5 requires a shorter pumping distance and a lesser lift (2 to 16 m [6 to 50 ft]). Both alternatives will require significantly increasing amounts of energy as population (and sewage volume) increases.

Alternative 6 conserves energy most effectively of all the alternatives while still achieving the quality and service goals specified. By not building additional facilities until first-phase 1,900 cu m per day [0.5 mgd] capacity is reached, energy consumption can be kept closer to actual need.

Alternative 1 will not affect existing energy demand.

All alternatives, except alternative 1, will commit community and national economic resources in a manner which may be viewed as irretrievable. However, if a dollar value could be placed upon the improved stream water quality, such commitment of resources would be easily viewed as at least in part retrievable.

All alternatives except alternative 1 would make possible increased rates of population growth in the area. The secondary impacts of this growth and development which constitute irreversible and irretrievable commitment of resources are: soil loss from eroded sites, loss of wildlife habitat (some of which is already in critically short supply), permanent loss of the aesthetic quality of the mountain area and commitment of national energy supplies to the periodic and frequent movement involved in second-home ownership.

# SECTION VIII

## RELATIONSHIP BETWEEN SHORT-TERM USES OF THE HUMAN ENVIRONMENT AND THE MAINTENANCE AND ENHANCEMENT OF LONG-TERM PRODUCTIVITY

Wastewater generation and the necessary management and disposal of wastewater is a long-term fact of life. Historically, solutions of the waste management problems have ignored this fact by providing short-term solutions which usually have had cumulative adverse effects over the long term upon the environment.

The provision of wastewater treatment facilities under any of the alternatives considered, involves uses of the human environment which are, or can be readily made to be, reasonably consistent with the maintenance and enhancement of long-term productivity. It is true that discharge of effluent to streams often involved risks to the aquatic habitat and usually reduces water quality for the downstream users. It is also true that land disposal and crop irrigation with effluent on a given site are short-term uses which over the long term deteriorate some of the properties of the land application areas (heavy metals buildup, groundwater quality degradation, limited access by humans to the vicinity of the sites).

Nonetheless, with improved effluent characteristics produced with advanced processes and with continued exemplary operation of the facilities, both modes of disposal can be made nearly consistent with the long-term interests of environmental preservation. Solutions that seem efficient for long-term productivity at this time might not be viewed as such by 1995. There will be improved technology, greater experience with land application and perhaps breakthroughs in other technologies which may have great impact on wastewater management.

None of the alternatives considered here can be viewed strictly as a short-term use of man's environment. Any unmitigated adverse impact of an action, no matter how small, will be incorporated into the ecosystem and may be magnified over time. Thus, it is necessary to view the utilization of stream and/or land as receiving media not in terms of short-term use of man's environment, but in its true perspective. An immediate consequence of such a view is that there must be minimal conflict between effluent disposal practices and environmental productivity. This makes adoption of mitigative provisions enumerated in Section VI important under any alternative selected.

A secondary, related short-term use of environment is the land development activity which is a motivating force behind the proposed wastewater treatment plant capacity expansion. It is a short-term use of the environment for those who develop and profit from the land today. It brings long-term waste generation sources to these headwaters of the Colorado River System. The balance between the short-term profitability of land development in these mountain areas and the long-term productivity of the environment is subject to question, emphasizing that proper land use planning and enforcement are extremely important.

# SECTION IX

## COORDINATION WITH AGENCIES

In the process of development, review, revision and upgrading of this document, numerous public and private agencies and persons were consulted in order to gain the correct dimensions and perspectives for the reader. While not all of these agencies have reviewed the whole document at this stage, their collective input has helped to make it an informational document for the public and a decision-making tool for EPA. Between publication of this Draft EIS and its finalizations, all these agencies and persons, among others, will be provided opportunities to comment on the material presented herein. These comments will provide an important link in the EIS process and the accomplishment of its prime objective: protection of our environment.

### LOCAL AGENCIES

Granby Sanitation District
Town of Granby
Grand County Commissioners
Grand County Department of Planning and Development
Grand County Department of Environmental Health
Grand County Assessor's Office
Grand County Department of Social Services
East Grand School District
Granby Finance Director
Granby Water Commissioner
Granby Chamber of Commerce
Mayor of Granby
Granby Police Department

### STATE AND REGIONAL AGENCIES

Northern Colorado Water Conservancy District
Colorado Department of Health, Water Quality Control Division
Colorado State University, College of Forestry and Natural Resources
Colorado Department of Health, Air Quality Control Division
Colorado State Department of Highways
Colorado State University, Department of Anthropology
Colorado State Highway Commission
Colorado Division of Game, Fish and Wildlife

## FEDERAL AGENCIES

U.S. Bureau of Reclamation
U.S. Geological Survey
U.S. Forest Service
U.S. Department of Agriculture, Soil Conservation Service
U.S. Bureau of Land Management
U.S. National Park Service

## PRIVATE AGENCIES AND ORGANIZATIONS

Sierra Club, Rocky Mountain Chapter
Del E. Webb Corporation/Val Moritz
N.H.P.Q., Inc.
Grand County Land Fill and Trash Removal
Mountain Park Electric, Inc.
Mountain Bell Telephone
Rocky Mountain Airways, Granby Airport
Leonard Rice Engineers
Climax Molybdenum Company, a Division of AMAX, Inc.
Denver and Rio Grande Western Railway Company
Continental Trailways

# SECTION X

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# APPENDIX A

# SOILS

The primary source for the following discussion is the preliminary results of a detailed soil survey of the eastern portion of Grand County, including the study area, conducted by the USDA Soil Conservation Service.

## GENERAL SOIL CHARACTERISTICS AND DISTRIBUTION

Within the Granby Quadrangle some 30 soil series have been distinguished and characterized. A list of these series, with corresponding symbols, is presented in Table A-1. A preliminary soil map of the Granby Quadrangle is shown on Figure 7 in Section III. The map symbols used in the figure are followed by a letter which designates slope. The pertinent properties of the soils most frequently encountered within the study area are presented in Table A-2, again using the symbols from Table A-1 and Figure 7; additional properties can be obtained from the Kremmling Office of the USDA Soil Conservation Service.

### Suitability of Soils for Septic Tank Filter Fields

The soils in the study area are marginally suitable to highly unsuitable for use as septic tank filter fields. Slow soil permeability, proximity of soil surface to bedrock and excess cobbles and stones in the soil are a few of the most common limiting factors. As with any application of soil maps, this conclusion is subject to field verification, with proper percolation tests and borings, for any given site. In developed areas, where population is concentrated, lot size, length of leach lines and required special design features would effectively preclude the use of septic tanks and leach fields as a means of on-lot wastewater disposal. Possible exceptions may be found on small portions of the Granby Mesa where Hierro or Frisco-peeler is encountered (map symbols 73 and 70).

### Suitability of Soils for Land Application of Effluent

Relative limitations of the various predominant soils in the study area *vis-a-vis* land application of wastewater effluents are summarized in Table A-2. Most soils which are suitable for crop production (i.e., Table A-1. LIST OF SOIL SERIES NAMES (AND CORRESPONDING MAP SYMBOLS) IN GRANBY QUADRANGLE

| Soil series and type | Map symbol used in Figure 4 |
|---|---|
| Clayburn loam | 3 and/or 71 |
| Cumulic Cryaquolls --- | 4 |
| Handran sandy loam | 12 |
| Bearmouth sandy loam | 15 |
| Scout gravelly sandy loam | 17 and/or 77 |
| Forelle loam | 19 |
| Leavitt loam | 20 |
| Aaberg clay loam | 23 |
| Hitchen clay loam | 25 |
| Binco clay loam | 26 |
| Cimarron loam | 27 |
| Mayworth clay loam | 28 |
| Roxal loam | 33 |
| Woodhall stony loam | 35 |
| Gateway loam | 38 |
| Cebone loam | 39 |
| Anvik loam | 40 |
| Grenadier loam | 43 |
| Lake Creek loam | 46 |
| Leadville loam | 47 |
| Rockland --- | 51 |
| Rogert gravelly sandy loam | 58 |
| Emerald loam | 59 |
| Yovimpa clay loam | 60 |
| Peeler coarse sandy loam | 70 |
| Cowdrey loam | 72 |
| Hierro loam | 73 |
| Youga loam | 74 |
| Quandy cobbly loam | 75 and/or 76 |
| Upson sandy loam | 79 |

Source: Preliminary soil survey interpretations supplied by U.S. Soil Conservation Service, Kremmling, Colorado.

## Table A-2. SELECTED CHARACTERISTICS OF PREDOMINANT SOILS IN GRANBY AREA

| Map symbol | Soil series (surface texture) | Relevance to project | Permeability cm/hr [in./hr] | Relative erodi-bility$^{a}$ | Shrink-swell potential | Corrosivity to | | Limitation$^{b}$ for use in | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | steel | con-crete | Septic tank leach field | Sewage lagoon | Land application of effluent | Crop production |
| 74 | Youga (loam) | Land application-crop | .2 to 5 [.06 to 2] | slight | low-moderate | high | low | 2-15%:severe$^{1}$<br>>15%:severe$^{1,2}$ | 2-7%:moderate$^{2}$<br>>7%:severe$^{2}$ | slight | 2-25%:severe<br>>25%:very severe |
| 4 | Cryaquolls (sandy loam, loam) | Sewage treatment plant sites 1, 2, 3, 4 | .2 to>50.8 [.06 to>20] | --- | low | high | low | severe$^{3}$ | severe$^{3,4}$ | moderate-severe$^{3}$ | severe |
| 27 | Cimarron (loam) | Residential developments land application-forest | .2 to 5.1 [.06 to 2] | moderate-high | low-high | high | low | 2-15%:severe$^{1}$<br>>15%:severe$^{1,2}$ | 2-7%:moderate$^{2}$<br>>7%:severe$^{2}$ | moderate | severe |
| 12 | Handran (stony sandy loam) | Land application-crop | 15 to 50 [6 to 20] | slight | low | mod. | low | 2-15%:severe$^{5}$<br>>15%:severe$^{2,5}$ | 2-7%:severe$^{5,6}$<br>>7%:severe$^{2,5,6}$ | moderate$^{3}$ | very severe |
| 47 | Leadville (loam) | Residential developments | 1.5 to 5 [.6 to 2] | moderate | low | high | mod. | 2-15%:severe$^{5}$<br>>15%:severe$^{2,5}$ | 2-7%:severe$^{5}$<br>>7%:severe$^{2,5}$ | slight | 2-25%:severe<br>>25%:very severe |
| 79 | Upson (sandy loam) | Residential developments | 5 to 50 [2 to 20] | slight | low | high | low | 3-15%:severe$^{7}$<br>>15%:severe$^{2,7}$ | 3-7%:severe$^{7,8}$<br>>7%:severe$^{2,7,8}$ | moderate | 3-25%:severe<br>>25%:very severe |
| 46 | Lake Creek (loam) | Residential developments | 2 to 50 [.6 to 20] | --- | low | high | low | severe$^{2,7}$ | severe$^{2,7}$ | severe | 15-25%:severe<br>>25%:very severe |
| 25 | Hitchen (clay loam) | Residential developments | .2 to 2 [.06 to .6] | high | moderate-high | high | high | 4-15%:severe$^{1,7}$<br>>15%:severe$^{1,2,7}$ | 4-7%:severe$^{7}$<br>>7%:severe$^{2,7}$ | moderate$^{7}$ | very severe |
| 26 | Binco (clay loam) | Residential developments land applic.-crop | .2 to 2 [.06 to .6] | moderate-high | moderate-high | high | mod. | severe$^{1}$ | 2-7%:slight<br>>7%:severe$^{2}$ | moderate-severe$^{1}$ | severe |

## Table A-2 (continued). SELECTED CHARACTERISTICS OF PREDOMINANT SOILS IN GRANBY AREA

| Map symbol | Soil series (surface texture) | Relevance to project | Permeability cm/hr [in./hr] | Relative erodibility[a] | Shrink-swell potential | Corrosivity to | | Limitation[b] for use in | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | steel | concrete | Septic tank leach field | Sewage lagoon | Land application of effluent | Crop production |
| 75-76 | Quander (loam) | Land application-crop; sewage treatment plant site 5 | 1.5 to 15.2<br>[.6 to 6] | slight | low-moderate | high | low | 0-15%:severe$^{5}$<br>>15%:severe$^{2,5}$ | 0-7%:severe$^{5}$<br>>7%:severe$^{2,5}$ | slight-moderate | 0-25%:severe<br>>25%:very severe |
| 70 | Peeler (gravelly coarse sandy loam) | Land application-crop | 1.5 to 50.8<br>[.6 to 20] | slight-moderate | low | mod.-high | low | 2-8%:slight<br>8-15%:moderate$^{2}$<br>>15%:severe$^{2}$ | 2-7%:severe$^{8}$<br>>7%:severe$^{2,8}$ | slight | 2-3%:severe<br>>25%:very severe |
| 72 | Cowdrey (very fine sandy loam) | Land application-forest | .2 to 5.1<br>[.06 to 2] | moderate | low-high | high | low | 0-15%:severe$^{1}$<br>>15%:severe$^{1,2}$ | 0-2%:slight<br>2-7%:moderate$^{2}$<br>>7%:severe$^{2}$ | slight | 0-25%:severe<br>>25%:very severe |
| 73 | Hierro (loam) | Land application-forest, crop; residential developments | 1.5 to 15.2<br>[.6 to 6] | moderate | low | high | low | 2-8%:slight<br>8-15%:moderate$^{2}$<br>>15%:severe$^{2}$ | 2-7%:moderate$^{8}$<br>>7%:severe$^{2}$ | slight | 2-25%:severe<br>>25%:very severe |

[a] The relative erodibilities given are strictly functions of soil properties. Other factors, such as slope, vegetation, precipitation, slope length and management practices also have important bearing on total erosion.

[b] Limitations are caused by various factors, defined below, and are functions of slope ranges given. Reference in the table to these definitions is made by superscript.

1 - slow percolation rates
2 - steep slope
3 - wet, floods--high groundwater
4 - excess humus
5 - large stones
6 - rapid percolation rates
7 - depth to rock
8 - seepage

Source: Adapted and derived from preliminary data supplied by U.S.D.A. Soil Conservation Service, Kremmling, Colorado.

those on gentle slopes, with developed soil deep enough for root penetration) present slight limitations for land application of effluents. In the areas of Granby near the riverbeds, proximity to groundwater table poses a severe limitation. Most of the soils suitable for land application occur north of Granby on the Granby Mesa or along the Colorado River below Lake Granby.

## Soils as a Natural Resource

The most important use of a soil, under both natural and managed conditions, is to support plant life. Under natural conditions, the particular limitations of a soil, such as its depth, fertility, waterholding capacity, etc., largely determine the intensity of growth of vegetation and the rate of biomass production. Under managed conditions, resources added to the soil by man through irrigation, fertilization, tillage, etc. can substantially alter its ultimate productivity. In the Granby area, a combination of rather low natural productivity in most soils and steep slopes in many parts renders nearly all the soils in the study area severely to very severely limited in their capability to yield crops. The limitations are aggravated by adverse climatic conditions and the ready erodibility of the soils. Stoniness and proximity to groundwater table are among problems that play a minor role. A single exception to the low capability rating of these soils is the Forelle series (map symbol 19). There is a relatively small area (about 12 hectares [30 acres]) of this soil 2 km [1.3 miles] south of Granby which, under irrigated agriculture, can produce commercial yields of grass hay, pasture, alfalfa hay, oats or barley.

Thus, it is possible to generalize that the land in the study area is not of prime agricultural importance. Nonetheless, the ability of the area to support lush natural vegetation under the limited rainfall conditions is an important fact and makes soil conservation practices an integral part of any project undertaken.

# APPENDIX B

## BIOTIC COMMUNITIES

Table B-1. PLANTS AND THEIR PROBABLE OCCURRENCE WITHIN STUDY AREA

| | | Biotic communities | | | | |
|---|---|---|---|---|---|---|
| Common name | Scientific name | Sagebrush 1 | Lodgepole Pine 2 | Grassland-Agricult. 3 | Riparian and Aquat. 4 | Aspen 5 |
| **Trees** | | | | | | |
| Aspen | *Populus tremuloides* | | x | | | x |
| Colorado blue spruce | *Picea pungens* | | x | | | |
| Douglas-fir | *Pseudotsuga menziesii* | | x | | | x |
| Engelmann spruce | *Picea engelmannii* | | x | | | x |
| Limber pine | *Pinus flexilis* | | x | | | x |
| Lodgepole pine | *Pinus contorta var. latifolia* | | x | | | x |
| Mountain alder | *Alnus tenuifolia* | | | | x | |
| Peachleaf willow | *Salix amygdaloides* | | | | x | |
| Subalpine fir | *Abies lasiocarpa* | | x | | | x |
| **Shrubs** | | | | | | |
| Bear-berry | *Arctostaphylos uva-ursi* | | x | | | x |
| Big sagebrush | *Artemisia tridentata* | x | | x | x | x |
| Bitterbrush | *Purshia tridentata* | | x | x | | x |
| Buffalo-berry | *Shepherdia canadensis* | | x | | | x |
| Common juniper | *Juniperus communis* | | x | | | x |
| Currant | *Ribes cereum* | | x | | x | x |
| Dwarf rabbitbrush | *Chrysothamnus viscidiflorus* | x | | | x | x |
| Huckleberry | *Vaccinium scoparium* | | x | | | x |
| Oregon grape | *Mahonia aquifolium* | | x | x | | x |
| Rabbitbrush | *Chrysothamnus nauseosus* | x | | x | x | |
| Rose | *Rosa* sp. | x | x | | | x |
| Shrubby cinquefoil | *Potentilla fruticosa* | x | x | x | x | x |
| Spirea | *Spiraea splendens* | | | | | x |
| Willow | *Salix* spp. | | | x | x | |
| **Herbs** | | | | | | |
| Alfalfa | *Medicago sativa* | | | x | | |
| Aster | *Aster* sp. | x | | x | | |
| Bedstraw | *Galium boreale* | | | | x | |
| Buckwheat | *Eriogonum* sp. | | x | x | | |
| Bulrush | *Scirpus* sp. | | | | x | |
| Canada thistle | *Cirsium arvense* | x | | x | | x |
| Cinquefoil | *Potentilla* sp. | | x | x | x | |
| Clover | *Trifolium* spp. | | | x | x | |

## Table B-1 (continued). PLANTS AND THEIR PROBABLE OCCURRENCE WITHIN STUDY AREA

|  |  | Biotic communities |  |  |  |  |
|---|---|---|---|---|---|---|
| Common name | Scientific name | Sagebrush 1 | Lodgepole Pine 2 | Grassland-Agricult. 3 | Riparian and Aquat. 4 | Aspen 5 |
| **Herbs**, cont'd |  |  |  |  |  |  |
| Colorado blue columbine | *Aquilegia caerulea* |  | x |  |  | x |
| Crazyweed | *Oxytropis* sp. | x | x |  |  |  |
| Curly dock | *Rumex crispus* | x |  |  | x |  |
| Daisy | *Erigeron* sp. | x |  |  | x |  |
| Dandelion | *Taraxacum officinale* | x | x |  | x | x |
| Dogfennel | *Anthemis cotula* | x |  | x |  |  |
| Elephanthead | *Pedicularis groenlandica* |  |  |  | x |  |
| Evening primrose | *Oenothera caespitosa* |  |  |  |  | x |
| False lupine | *Thermopsis montana* |  |  |  |  | x |
| Fanweed | *Thlaspi arvense* |  |  |  | x |  |
| Fireweed | *Epilobium angustifolium* |  | x |  |  | x |
| Goatweed | *Hypericum perforatum* |  |  |  | x |  |
| Goldenrod | *Solidago canadensis* |  |  |  | x |  |
| Harebell | *Campanula rotundifolia* |  | x | x |  | x |
| Larkspur | *Delphinium* sp. |  |  |  |  | x |
| Little penstemon | *Penstemon procerus* |  | x |  |  |  |
| Locoweed | *Astragalus* sp. | x |  | x | x | x |
| Lupine | *Lupinus* sp. | x | x | x |  | x |
| Mat penstemon | *Penstemon caespitosus* | x |  |  |  |  |
| Monkshood | *Aconitum* sp. |  |  |  |  | x |
| Monument plant | *Frasera speciosa* | x |  | x |  |  |
| Mountain ball cactus | *Pediocactus simpsonii* | x |  |  |  |  |
| Mountain hollyhock | *Iliamna rivularis* |  |  |  | x |  |
| Mule's ears | *Wyethia amplexicaulis* | x |  | x |  |  |
| Owl clover | *Orthocarpus* sp. |  | x |  | x |  |
| Pasqueflower | *Pulsatilla ludoviciana* |  | x |  |  |  |
| Pearly everlasting | *Anaphalis margaritacea* |  |  |  |  | x |
| Peavine | *Lathyrus leucanthus* |  |  |  |  | x |
| Peppergrass | *Lepidum virginicum* | x |  |  | x |  |
| Phlox | *Phlox bryoides* | x |  |  |  |  |
| Prostrate knotweed | *Polygonum aviculare* |  |  |  | x |  |
| Pussytoes | *Antennaria rosea* | x |  |  | x |  |
| Rush | *Juncus* spp. |  | x | x | x |  |
| Scarlet gilia | *Gilia aggregata* |  | x |  |  |  |
| Sedge | *Carex* spp. |  |  |  | x |  |
| Sego lily | *Calochortus nuttallii* | x |  |  | x | x |
| Showy mountain daisy | *Erigeron speciosa* |  |  |  | x |  |

## Table B-1 (continued). PLANTS AND THEIR PROBABLE OCCURRENCE WITHIN STUDY AREA

| Common name | Scientific name | Biotic communities<br>Sagebrush 1 | Lodgepole Pine 2 | Grassland-Agricult. 3 | Riparian and Aquat. 4 | Aspen 5 |
|---|---|---|---|---|---|---|
| **Herbs, cont'd** | | | | | | |
| Silverweed | *Potentilla anserina* | | | | x | |
| Smooth dock | *Rumex altissimus* | | | | x | |
| Stemless Colorado thistle | *Cirsium coloradense var. acaulescens* | | | | x | |
| Stickseed | *Lappula sp.* | | | | x | |
| Sticky aster | *Aster bigelovii* | | | | x | |
| Stinging nettle | *Urtica dioica ssp. gracilis* | | | | x | |
| Sulphur flower | *Eriogonum umbellatum* | x | | x | x | x |
| Tansy mustard | *Descurainia pinnata* | x | | x | x | |
| Thickstem aster | *Aster integrefolius* | | | x | | |
| Vetch | *Vicia americana* | | x | | | |
| White phlox | *Phlox multiflora* | x | | | | |
| Wild flax | *Linum lewisii* | | | | | x |
| Windflower | *Anemone multifida* | | | | x | |
| Yarrow | *Achillea lanulosa* | x | | x | x | |
| Yellow sweetclover | *Melilotus officinalis* | x | | x | | |
| Yellowweed | *Solidago elongata* | | | | x | |
| **Grass** | | | | | | |
| Alpine timothy | *Phleum alpinum* | | | x | x | |
| American sloughgrass | *Beckmannia syzigachne* | | | | x | |
| Bentgrass | *Agrostis sp.* | | | | x | |
| Bluebunch wheatgrass | *Agropyron spicatum* | x | | | | |
| Crested wheatgrass | *Agropyron desertorum* | | | | x | |
| Foxtail barley | *Hordeum jubatum* | x | | x | x | |
| Idaho fescue | *Festuca idahoensis* | x | | x | | |
| Junegrass | *Koeleria gracilis* | x | | x | | |
| Kentucky bluegrass | *Poa pratensis* | | | x | | x |
| Letterman needlegrass | *Stipa lettermani* | | | x | | |
| Mountain brome | *Bromus marginatus* | | x | | | x |
| Mountain muhly | *Muhlenbergia montana* | | | x | | |
| Muhly | *Muhlenbergia sp.* | | | | x | |
| Muttongrass | *Poa fendleriana* | x | | x | | |
| Needle-and-thread | *Stipa comata* | | | x | | |
| Needlegrass | *Stipa sp.* | | | | x | |
| Nodding brome | *Bromus porteri* | | x | | | x |
| Pine needlegrass | *Stipa pinetorum* | x | | | | |
| Red fescue | *Festuca rubra* | | | x | x | |

### Table B-1 (continued). PLANTS AND THEIR PROBABLE OCCURRENCE WITHIN STUDY AREA

| | | Biotic communities | | | | |
|---|---|---|---|---|---|---|
| Common name | Scientific name | Sagebrush 1 | Lodgepole Pine 2 | Grassland-Agricult. 3 | Riparian and Aquat. 4 | Aspen 5 |
| **Grass**, cont'd | | | | | | |
| Redtop | *Agrostis alba* | | | x | x | x |
| Reflexed bluegrass | *Poa reflexa* | | | x | x | |
| Sheep fescue | *Festuca saximontana* | | | x | | |
| Slender wheatgrass | *Agropyron trachycaulum* | | x | | | x |
| Smooth brome | *Bromus inermis* | | | x | | x |
| Spike trisetum | *Trisetum spicatum* | | x | x | | |
| Squirreltail | *Sitanion hystrix* | x | x | | | x |
| Thurber bentgrass | *Agrostis thurberiana* | | | | x | |
| Thurber's fescue | *Festuca thurberi* | | | x | | x |
| Timothy | *Phleum pratense* | | x | x | x | x |
| Tufted hairgrass | *Deschampia caespitosa* | | | x | | |
| Western wheatgrass | *Agropyron smithii* | x | | x | x | x |
| Wild oat | *Avena fatua* | | | x | | |

### Table B-2. MAMMALS AND THEIR PROBABLE OCCURRENCE WITHIN STUDY AREA[a]

| Common name | Scientific name | Biotic communities<br>Sagebrush<br>1 | Lodgepole Pine<br>2 | Grassland-Agricultural<br>3 | Riparian and Aquatic<br>4 | Aspen<br>5 |
|---|---|---|---|---|---|---|
| Snowshoe hare | *Lepus americanus* |  | C |  |  |  |
| White-tailed jackrabbit | *Lepus townsendii* | C |  | C |  |  |
| Mountain cottontail | *Sylvilagus nuttallii* | O |  | O | R | R |
| Richardson's ground squirrel | *Spermophilus richardsonii* | A |  | A |  |  |
| Spotted ground squirrel | *Spermophilus spilosoma* | R |  | R |  |  |
| Golden mantled ground squirrel | *Spermophilus lateralis* |  | C |  |  |  |
| Red squirrel | *Tamiasciurus hudsonicus* |  | C |  |  |  |
| Colorado chipmunk | *Eutamias quadrivittatus* | C | A |  |  | C |
| Yellow-bellied marmot | *Marmota flaviventris* | C |  | C |  |  |
| Deer mouse | *Peromyscus maniculatus* | A | C | A | C | A |
| Bushy-tailed woodrat | *Neotoma cinerea* | C | C |  |  |  |
| Meadow vole | *Microtus pennsylvanicus* | O |  | C | C |  |
| Mountain vole | *Microtus montanus* | C | O | C |  | O |
| Beaver | *Castor canadensis* |  |  |  | C |  |
| Muskrat | *Ondatra zibethicus* |  |  |  | O |  |
| Porcupine | *Erethizon dorsatum* |  | C |  |  |  |
| Coyote | *Canis latrans* | C | C | C | C | C |
| Red fox | *Vulpes fulva* | O | O |  |  | O |
| Gray wolf | *Canis lupus* |  | R |  |  |  |
| Black bear | *Euarctos americanus* |  | C |  |  |  |
| Raccoon | *Procyon lotor* |  |  |  | C | O |
| Long-tailed weasel | *Mustela frenata* | O | C | O |  | C |
| Mink | *Mustela vison* |  |  |  | O |  |
| Badger | *Taxidea taxus* | C |  | C |  |  |
| Striped skunk | *Mephitis mephitis* | C | C | C | O | C |
| Bobcat | *Lynx rufus* | O | O |  |  | O |
| Rocky mountain elk | *Cervus canadensis* | C | C | C |  | A |
| Mule deer | *Odocoileus hemionus hemionus* | A | C | C |  | C |
| Pronghorn antelope | *Antilocapra americana* | R |  | R |  |  |

[a] Key to occurrence: A = abundant C = common
O = occasional R = rare

## Table B-3. BIRD SPECIES AND THEIR PROBABLE OCCURRENCE WITHIN STUDY AREA[a]

| | | Biotic communities | | | | |
|---|---|---|---|---|---|---|
| | | Sagebrush | Lodgepole Pine | Grassland-Agricultural | Riparian and Aquatic | Aspen |
| Common name | Scientific name | 1 | 2 | 3 | 4 | 5 |
| Eared grebe | *Podiceps caspicus* | | | | R | |
| Great blue heron | *Ardeo herodias* | | | | O | |
| Canada goose | *Branta canadensis* | | | | R | |
| Mallard | *Anas platyrhynchos* | | | | C | |
| Gadwall | *Anas strepera* | | | | O | |
| Pintail | *Anas acuta* | | | | O | |
| Green-winged teal | *Anas carolinensis* | | | | C | |
| Northern shoveler | *Spatula clypeata* | | | | C | |
| Bufflehead | *Bucephala albeola* | | | | C | |
| Goshawk | *Accipiter gentilis* | | O | | | O |
| Red-tailed hawk | *Buteo jamaicensus* | C | C | O | O | O |
| Swainson's hawk | *Buteo swainsoni* | O | O | O | O | O |
| Marsh hawk | *Circus cyaneus* | O | | O | | |
| Golden eagle | *Aquila chrysaetos* | C | C | | | O |
| Southern bald eagle | *Haliaeetus leucophalus* | | | | R | |
| Sparrow hawk | *Falco sparverius* | C | | C | | |
| Peregrine falcon | *Falco peregrinus* | | | | R | |
| Prairie falcon | *Falco mexicanus* | O | | O | | |
| Blue grouse | *Centrocercus urophasianus* | | C | | | |
| Sage grouse | *Dendrogapus obscurus* | C | | | | C |
| American coot | *Fulica americana* | | | | C | |
| Killdeer | *Charadrius vociferus* | | | O | C | |
| Spotted sandpiper | *Actitis macularia* | | | | O | |
| Common snipe | *Capella gallinago* | | | | O | |
| Wilson's phalarope | *Steganopus tricolor* | | | | O | |
| Band-tailed pigeon | *Columba fasciata* | R | R | | | |
| Mourning dove | *Zenaidura macroura* | C | | C | O | C |
| Screech owl | *Otus asio* | | O | | | |
| Great horned owl | *Bubo virginianus* | | O | | | |
| Short-eared owl | *Asio flammeus* | O | | O | O | |
| Burrowing owl | *Speotyto cunicularia* | R | | R | | |
| Poor-will | *Phalaenoptilus nuttallii* | C | | C | | |
| Common nighthawk | *Chordeiles minor* | C | O | C | | |

## Table B-3 (continued). BIRD SPECIES AND THEIR PROBABLE OCCURRENCE WITHIN STUDY AREA[a]

| | | Biotic communities | | | | |
|---|---|---|---|---|---|---|
| Common name | Scientific name | Sagebrush 1 | Lodgepole Pine 2 | Grassland-Agricultural 3 | Riparian and Aquatic 4 | Aspen 5 |
| Broad-tailed hummingbird | *Selasphorus platycercus* | O | C | C | C | |
| Rufous hummingbird | *Selasphorus rufus* | | | C | C | |
| Belted kingfisher | *Megaceryle alcyon alcyon* | | | | O | |
| Red-shafted flicker | *Colaptes cafer collaris* | | C | O | | C |
| Hairy woodpecker | *Dendrocopos villosus* | | C | | | |
| Downy woodpecker | *Dendrocopos pubescens* | | C | | | C |
| Western kingbird | *Tyrannus verticalis* | | | O | | O |
| Eastern kingbird | *Tyrannus tyrannus* | | | R | | R |
| Traill's flycatcher (willow) | *Empidonax traillii brewsteri* | O | | | R | |
| (alder) | *Empidonax traillii traillii* | O | | | R | |
| Dusky flycatcher | *Empidonax obholseri* | O | O | | | |
| Horned lark | *Eremophila alpestris* | C | | C | | |
| Violet-green swallow | *Tachycineta thalassina* | | | | C | C |
| Tree swallow | *Irodoprocne bicolor* | | | | C | |
| Bank swallow | *Riparia riparia* | | | C | C | |
| Rough-winged swallow | *Stelgidopteryx ruficollis* | | | | C | |
| Barn swallow | *Hirundo rustica* | | | C | C | |
| Cliff swallow | *Petrochelidon pyrrhonota* | | | | C | |
| Gray jay | *Perisoreus canadensis* | | C | | | |
| Stellers jay | *Cyanocitta stelleri* | | O | | | |
| Pinon jay | *Gymnorhinus cyanocephala* | O | | | | |
| Black-billed magpie | *Pica pica* | A | | A | O | A |
| Common raven | *Corvus corax* | C | | C | | O |
| Common crow | *Corvus brachrhynchos* | C | | C | | C |
| Clark's nutcracker | *Nucifraga columbiana* | | C | | | |
| Black-capped chickadee | *Parus atricapillus* | C | C | | | C |
| Mountain chickadee | *Parus gambeli* | | C | | | |
| Bushtit | *Psaltripus minimus* | O | | | | O |
| House wren | *Troglodytes aedon* | C | C | | C | C |
| Rock wren | *Salpinctes obsoletus* | | C | | | C |
| Sage thrasher | *Oreoscoptes montanus* | C | | O | | |

## Table B-3 (continued). BIRD SPECIES AND THEIR PROBABLE OCCURRENCE WITHIN STUDY AREA[a]

| Common name | | Biotic communities | | | | |
|---|---|---|---|---|---|---|
| | | Sagebrush 1 | Lodgepole Pine 2 | Grassland-Agricultural 3 | Riparian and Aquatic 4 | Aspen 5 |
| American robin | *Turdus migratorius* | C | | C | C | C |
| Mountain bluebird | *Sialia currucoides* | C | | C | | |
| Townsend's solitaire | *Myadestes townsendi* | | O | | | |
| Ruby-crowned kinglet | *Regulus calendula* | | R | | R | R |
| Loggerhead shrike | *Lanius ludovicianus* | O | | O | O | |
| Yellow warbler | *Dendroica petechia* | | | | C | |
| Yellow-rumped warbler | *Dendroica audoboni* | | C | | C | C |
| Wilson's warbler | *Wilsonia pusilla* | | | | R | R |
| MacGillivray's warbler | *Oporornis tolmiei* | O | | | R | R |
| Western meadowlark | *Sturnella neglecta* | | | C | | |
| Yellow-headed blackbird | *Xanthocephalus xanthocephalus* | | | | C | |
| Red-winged blackbird | *Agelaius phoenicus* | | | | A | |
| Bullock's oriole | *Icterus bullockii* | | | | R | |
| Brewer's blackbird | *Euphagus cyanocephalus* | | | C | | |
| Brown-headed cowbird | *Molothrus ater* | | | C | | |
| Western tanager | *Piranga ludoviciana* | | O | | | |
| Common grackle | *Quiscalus quiscula* | | | O | O | |
| American goldfinch | *Spinus tristis* | | | O | O | O |
| Gray-crowned rosy finch | *Leucosticte tephrocotis* | O | | | | |
| Pine grosbeak | *Pinicola enucleator* | | C | | | |
| Green-tailed towhee | *Chlorura chlorura* | C | | O | O | O |
| Lark bunting | *Calamospiza melanocorys* | C | | C | | |
| Savannah sparrow | *Passerculus sandwichensis* | O | | O | | |
| Vesper sparrow | *Pooecetes gramineus* | A | | A | | |
| Cassin's sparrow | *Aimophila cassinnii* | R | | R | | |
| Gray-headed junco | *Junco caniceps* | O | C | | | O |
| Chipping sparrow | *Spizella passerina* | | C | | | |
| Brewer's sparrow | *Spizella breweri* | C | | C | | |
| White-crowned sparrow | *Zonotrichia leucophrys* | O | | | O | O |
| Lincoln's sparrow | *Melospiza lincolnii* | | | O | | O |
| Song sparrow | *Melospiza melodia* | | | | O | O |

[a] Key to occurrence: A = abundant C = common
O = occasional R = rare

# APPENDIX C

# NITRIFICATION

The treatment system recommended for the Granby Sanitation District in the Facilities Plan (Reference 1) is intended to produce a nitrified effluent. Because this is usually difficult to achieve in a cold climate (see Section III under Climate), it is worthwhile to examine the need for nitrification. The discussion that follows is prefaced by a brief description of the role of nitrogen forms in water quality management.

## NITROGEN FORMS

The nitrogen present in fresh sewage is primarily combined in proteinaceous matter and urea. Decomposition by bacteria, both in the sewer and in a conventional secondary wastewater treatment plant, reduces the various nitrogen compound forms to ammonia. After discharge to a stream, bacteria in the stream oxidize the ammonia to nitrites and nitrates.

The nitrogen forms discharged to a stream from a wastewater treatment plant affect stream ecology in three ways. First, oxidation of nitrogen forms imposes an oxygen demand on the stream waters which may deplete dissolved oxygen content to an unacceptable level. This process occurs somewhat more slowly than that attributable to carbonaceous oxygen demand. Second, the nitrogen forms may serve as a plant nutrient, leading to explosive growth of algae. Finally, ammonia has a direct toxic effect on aquatic life.

Within the Fraser-Williams Fork Subbasin, it has been determined that ammonia toxicity is the most critical factor with respect to the impact of wastewater discharges on the Fraser and Colorado rivers (Reference 2).

## AMMONIA TOXICITY

Ammonia in an aquatic environment is dissociated to a degree dependent upon pH and temperature:

$$NH_3 + H_2O \underset{\text{High pH, high temperature}}{\overset{\text{Low pH, low temperature}}{\rightleftharpoons}} NH_4^+ + OH^-$$

Several authors have reported that the harmful effects of ammonia are attributable to the un-ionized fraction of ammonia. Recent work has indicated that the highest concentration of un-ionized ammonia that can be tolerated by aquatic life without adverse effects is 0.025 mg/l (as ammonia). The un-ionized proportion of ammonia increases with rising pH and temperature. Table C-1 shows concentrations of total ammonia which contain 0.025 mg/l of un-ionized ammonia at different temperature and pH values. It is clearly evident that stream water pH and temperature are of critical importance in determining the maximum ammonia waste load that can be imposed on the stream without adverse effects. Differences in the tolerable ammonia concentration of several orders of magnitude can result from relatively small changes in pH and temperature.

Table C-1. CONCENTRATIONS OF TOTAL ($NH_4^+ + NH_3$) AMMONIA WHICH CONTAIN AN UN-IONIZED AMMONIA CONCENTRATION OF 0.02059 mg/l AMMONIA-NITROGEN

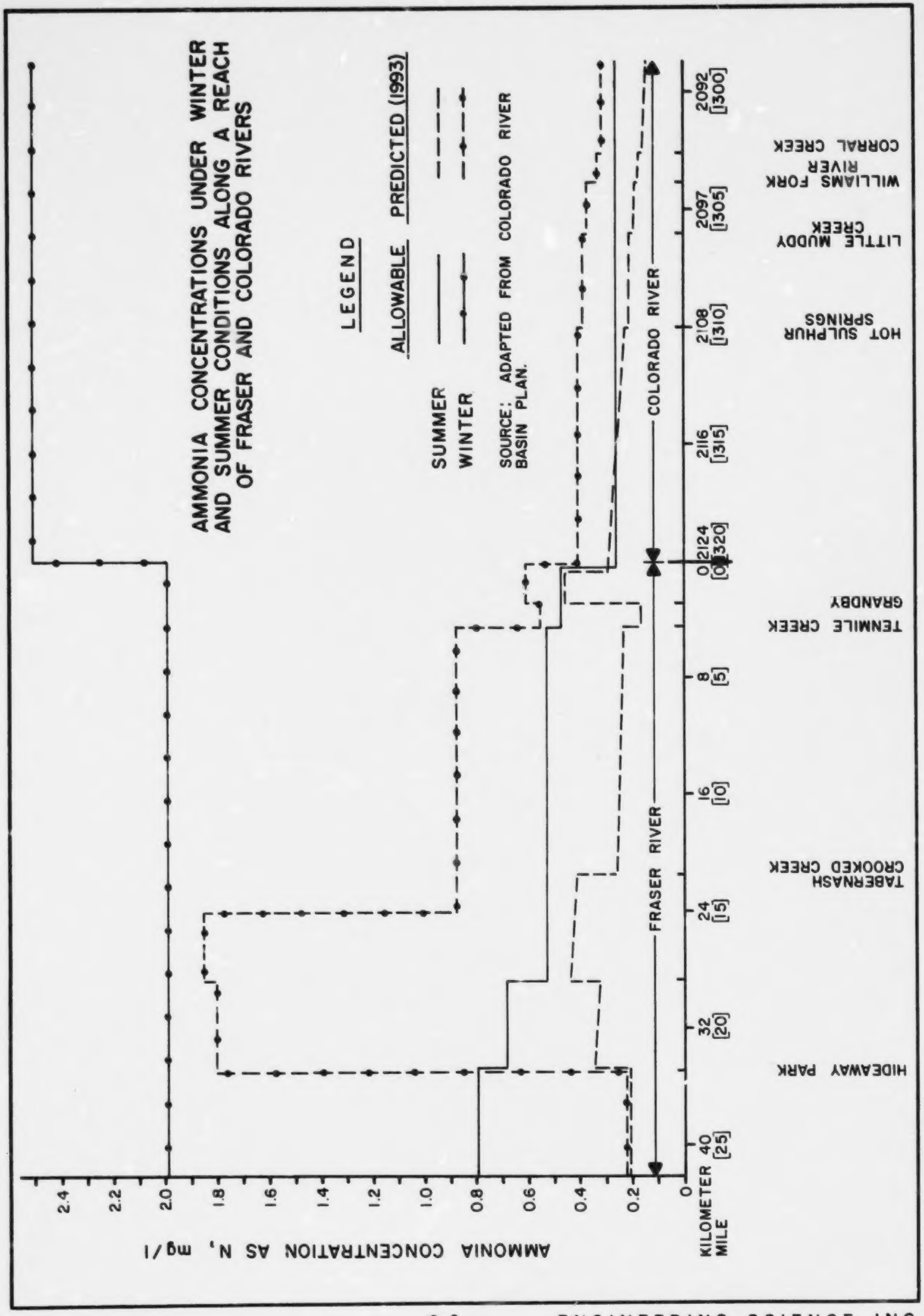
| Temperature, °C | pH value | | | | | | |
|---|---|---|---|---|---|---|---|
| | 6.0 | 6.5 | 7.0 | 7.5 | 8.0 | 3.5 | 9.0 |
| 5 | 165 | 52.2 | 16.5 | 5.24 | 1.67 | .542 | .1856 |
| 10 | 110.7 | 35.0 | 11.1 | 3.52 | 1.13 | .371 | .1313 |
| 15 | 75.5 | 23.9 | 7.57 | 2.41 | .776 | .2594 | .0961 |
| 20 | 51.7 | 16.37 | 5.19 | 1.656 | .5377 | .1841 | .0723 |
| 25 | 36.25 | 11.48 | 3.64 | 1.166 | .3829 | .1352 | .0568 |
| 30 | 25.53 | 8.09 | 2.57 | .827 | .2757 | .1013 | .0461 |

Reference: "Ammonia toxicity and its removal from wastewaters," Tom Willingham, EPA Region VIII, April 1973.

## ALLOWABLE AMMONIA CONCENTRATIONS IN THE FRASER RIVER AND THE COLORADO RIVER

As part of the Colorado River Basin Water Quality Management Planning Study, predictions of ammonia concentrations in the Fraser River and the Colorado River were made and are shown in Figure C-1. The recommended plan includes secondary treatment with nitrification to 1.5 mg/l ammonia-nitrogen at the Granby treatment plant. The dashed lines shown on Figure C-1 indicate allowable ammonia concentrations in the winter and summer based on measured pH and temperature values and the previously described characteristics of ammonia toxicity. During the winter, the predicted ammonia concentrations in the rivers are considerably below the allowable limit; in fact, even without nitrification, predicted ammonia concentrations remain below allowable concentrations. In the summer, predicted ammonia concentrations are close to the allowable, particularly in the stream segments below Granby. The waste load allocations shown in Table C-2 were based on this analysis and in turn were used to establish ammonia discharge requirements for the Granby Sanitation District. It was noted in the basin plan, however, that the

FIGURE C-1



AMMONIA CONCENTRATIONS UNDER WINTER AND SUMMER CONDITIONS ALONG A REACH OF FRASER AND COLORADO RIVERS

SOURCE: ADAPTED FROM COLORADO RIVER BASIN PLAN.

Table C-2. WASTE LOAD ALLOCATIONS FOR THE FRASER-WILLIAMS FORK SUBBASINS

| Location | Allocated low stream flow, cu m/s[a] | Historical temp, °C[b] | Historical pH[c] | Ammonia ($NH_3$-N) | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | Corresponding toxic level[d] | Assumed background | Allowable increase | Waste load allocation | Projected 1993 inputs for the Recommended Plan |
| | | | | (mg/l) | | | (kg/day)[e] | |
| Headwaters of the Fraser River to the Colorado confluence | | | | | | | | |
| Summer | 0.38 | 15.8 | 8.2 | 0.47 | 0.10 | 0.37 | 12.2 | 12.0 |
| Winter | 0.63 | 0 | 8.1 | 1.99 | 0.10 | 1.89 | 102 | 14.1 |
| Total lengths of the Colorado and Fraser rivers above Hot Sulphur Springs | | | | | | | | |
| Summer | 0.89 | 16.2 | 8.5 | 0.24 | 0.10 | 0.14 | 10.9 | 12.0 |
| Winter | 1.13 | 0 | 8.0 | 2.50 | 0.10 | 2.40 | 235 | 34.5 |

[a] One cu m/s = 35.31 cfs.

[b] Historical temperatures are those reported in *Waste Load Allocation for the Fraser River* and from the State RPS Station #45 at Hot Sulphur Springs.

[c] Historical pH values are derived from the State RPS Station #45 at Hot Sulphur Springs and from historical values on mountain streams similar to the Fraser River.

[d] Toxic concentrations, based on historical temperature and pH, were taken from the Region VIII EPA report *Ammonia Toxicity and Its Removal from Wastewaters*.

[e] One kg = 2.205 lb.

predictions were based on relatively sparse pH and temperature data. The following section examines the relationship between these parameters and the effluent requirements for Granby.

## EFFLUENT REQUIREMENTS FOR GRANBY

Considering the total summertime allocation of 12.2 kg/day [27 lb/day] of ammonia to the Fraser River upstream of its confluence with the Colorado, it is apparent that the greater part of the allocation can be assigned to Granby because at that season Granby's discharge represents 95 percent of the wastewater discharged to the reach. The corresponding effluent requirement, based on a 1990 flow of 5,700 cu m per day [1.5 mgd], is 2.1 mg/l ammonia-nitrogen.

The 12.2 kg/day [27 lb/day] allocation is based on a water temperature of 15.8°C [60°F] and a pH of 8.2. If the waste allocation is calculated on the basis of a pH value of 7.8 (an average of nine measurements near the Granby treatment plant obtained in August 1973), waste load allocation is increased to 30 kg/day [66 lb/day], with a corresponding increase in the ammonia effluent requirement to 5.1 mg/l. Thus it can be seen that, although a considerable degree of nitrification is necessary, if adverse effects are not to occur during critical low flows, it is probably not necessary to attain an ammonia effluent concentration of 0.5 or 1.5 mg/l as indicated in the Facilities Plan. The is particularly true if Val Moritz fails to develop.

## APPENDIX D

## THE ROTATING DISK WASTEWATER TREATMENT PROCESS

Conventional secondary level wastewater treatment processes employ biological action to remove most pollutants from wastewaters. In the United States, this has been traditionally accomplished with trickling filters, where sewage passes in a thin film over biological growths attached to rocks or plastic media, or with activated sludge, where a floc of microorganisms is kept suspended in an aerated medium of sewage. A different process has been used in Europe for several years and is now being used more and more widely here. This process promotes the growth of microorganisms on large disks which are vertically rotated, half-submerged, through a bath of wastewater. Proponents of the rotating disk system claim many operational advantages over other methods of biological treatment. This presentation will provide a brief review of the operation and feasibility of the rotating disk process.

Before biological treatment can begin, raw sewage must undergo primary sedimentation. This removes 60 to 70 percent of incoming suspended solids and 30 percent of incoming BOD for a typical municipal wastewater. Primary sedimentation is a prerequisite for rotating disks not so much for the reduction of organic loading as for the removal of larger suspended material that could coat or clog the openings between the disks.

The rotating disks are usually from 3 to 10 feet in diameter and arranged in multiples on long shafts. The disks are approximately 0.5 in. thick and spaced with 0.5 to 1 in. gaps between adjacent disks. Primary settled sewage flows perpendicular to the axis of the shaft and may pass through one or many shafts in succession; a typical number is four shafts in series. The rotating disks are immersed approximately half-way into the sewage and are turned approximately six times per minute. Biological growths on the surfaces of the disks alternately come into contact with pollutants in the wastewater, which are nutrients to them, and an abundant oxygen supply from the air. The pollutants are adsorbed onto the biological film and converted to cell mass, water and carbon dioxide. Periodically, the cell mass becomes too large and sloughs off the disk into the wastewater stream. After biological treatment, the wastewater passes into secondary clarifiers where the large particles of cell mass are settled out and removed.

Parameters or factors that would affect the performance of rotating disks in clarifying wastewaters are (1) hydraulic loading; (2) number of units in series; (3) organic loading and nutrients; (4) temperature; (5) pH; and (6) rotational speed and direction.

## OPERATING PARAMETERS

### Hydraulic Loading

Hydraulic loading can be expressed as retention time in the rotating disk reactors, but is properly stated as the volumetric rate of application per disk unit surface area. Typical loading rates for municipal wastewaters are on the order of 2 to 4 gallons per square foot per day [gal./(ft)$^2$(day)]. The degree of $BOD_5$ removal is inversely proportional to the hydraulic loading rate, with the lower rates achieving substantially better removals. Ammonia nitrogen removal occurs after most of the $BOD_5$ removal is completed. Nitrification appears to be most effective at hydraulic loading rates on the order of 1.0 to 1.5 gal./(ft)$^2$(day).

### Number of Stages

Primary wastewater can pass through one long stage of disks or through several shorter lengths placed in series. Most applications have used several stages in series. This appears to be the most effective due to decreasing nutrient levels at each successive stage, changing dissolved oxygen requirements, and different growth requirements of microorganisms in each stage. Various estimates have placed $BOD_5$ removal at 50 to 75 percent reductions per stage. Test results have shown that the majority of $BOD_5$ reductions occur at the initial stages of treatment. Construction of treatment stages beyond 3 or 4 allows a place for nitrifying organisms to grow and effectively lowers the hydraulic surface loading rate to a range acceptable for nitrification. Again, the surface loading rate appears to be the controlling parameter.

### Organic Loading and Nutrients

Treatment effectiveness of the rotating disk reactors cannot be expected to remain constant with wastewater feeds ranging from dairy wastes to refinery wastes. However, within the range of normal municipal wastewater quality variation, the rotating disk process can produce a reasonably constant effluent quality. This is based upon tests conducted in Pewaukee, Wisconsin, where daily peak storm flows were 2.4 to 4 times the average daily flow, with variations in $BOD_5$ concentration, and yet, effluent quality remained consistent (Reference 1). Rotating disk systems conservatively designed for cold-weather operation and adequate nitrification, would have little difficulty in adjusting to varying pollutant loads. However, the basic relationship of food to microorganisms cannot be ignored and, in general, substantial increases in $BOD_5$ loading will use more of the available treatment stages for $BOD_5$ removal and nitrification could occur later in the process stages or possibly not at all.

## Temperature

Temperature is an important factor controlling reaction rates and required rotating disk reactor sizes. Design manuals published by the Autotrol Corporation indicate relatively constant biological reaction rates at temperatures between 55°F and 75°F (Reference 2). At lower temperatures, substantially larger units would be necessary to achieve similar $BOD_5$ reductions. Typically, for 90 percent $BOD_5$ removal, a unit operating at a 41°F wastewater temperature would need to be twice as large in surface area as a unit operating at 55°F. Since a 90% $BOD_5$ removal is accomplished with a very conservatively designed unit at low loading rates on the order of 1.5 to 3.0 gal./$(ft)^2$(day), a more dramatic temperature correction can be seen for units designed for lower $BOD_5$ removals. A unit achieving 85 percent BOD removal at 55°F would have to be increased in size by 240 percent to achieve comparable removals at 40°F wastewater temperature. If the unit were not increased in size, $BOD_5$ removals would drop drastically. For the unit originally achieving 90% $BOD_5$ removal at 55°F, performance could drop to 70% $BOD_5$ removal at 40°F if the unit were not enlarged.

## pH

The pH ranges normally encountered in domestic wastewaters will not affect the rotating disc process. Extreme pH excursions caused by a sudden industrial "dump" could shock this or any other biological system. Due to the plug-flow nature of the rotating disk process, the shock would be more substantial than with a completely mixed activated sludge reactor which can provide very rapid dilution of toxic wastes. For rotating disk systems which may undergo substantial shock loads, 24-hour detention time equalization tanks would be recommended.

## Rotational Speed and Direction

For disks of approximately 10-foot diameter, rotational speeds on the order of 2 to 6 rpm appear to produce adequate liquor aeration and agitation and adequate biomass contact time as well as minimizing power input. Testing has indicated that a peripheral speed of 60 feet per minute optimizes BOD and ammonia nitrogen removal (Reference 3). Some researchers have tried to correlate rotational speed with nitrification and concluded that liquor aeration and agitation must be such as to first produce a BOD or COD reduction before nitrification can commence (Reference 4). Countercurrent rotation appeared to produce somewhat better removals than concurrent rotation (Reference 4).

## PUBLISHED PERFORMANCE RESULTS

### Pewaukee, Wisconsin (Reference 1)

These tests were conducted with municipal wastewaters.

| | | | | Concentration, mg/l | | | |
|---|---|---|---|---|---|---|---|
| Loading rate | Process stage | Temperature | pH | Dissolved oxygen | $BOD_5$ | Suspended solids | Ammonium nitrogen |
| 1 to 3 gal/ $(ft)^2$ (day) | primary effluent | 74° F | 7.6 | 1.1 | 114 | 105 | -- |
| | stage 1 | -- | -- | 1.0 | 63 | 89 | -- |
| | stage 2 | -- | -- | 1.2 | 40 | 72 | -- |
| | stage 3 | -- | -- | 1.9 | 29 | 79 | -- |
| | stage 4 | 74° F | 7.7 | 2.1 | 19 | 80 | -- |
| 0.47 to 0.83 gal/ $(ft)^2$ (day) | primary effluent | 63° F | 7.6 | 1.3 | 118 | -- | 14.1 |
| | stage 1 | -- | -- | 2.9 | 20 | -- | 11.3 |
| | stage 2 | -- | -- | 3.4 | 18 | -- | 3.2 |
| | stage 3 | -- | -- | 5.2 | 12 | -- | 0.6 |
| | stage 4 | 63° F | -- | 6.2 | 11 | -- | 0.4 |

### Dakota City, Nebraska (Reference 5)

These tests were conducted with anaerobic lagoon effluent treating slaughterhouse wastes.

| Hydraulic loading rate | Treatment stage | 4-ft diameter disk speed, rpm | Influent $BOD_5$, mg/l average | Effluent $BOD_5$, mg/l average | Cumulative $BOD_5$ removal, percent |
|---|---|---|---|---|---|
| 2.65 gal/ $(ft)^2$ (day) | 1 | 3 | 249 | 143 | 42.7 |
| | 2 | 3 | 143 | 147 | 41.0 |
| | 3 | 3 | 147 | 124 | 49.7 |
| 2.65 gal/ $(ft)^2$ (day) | 1 | 6 | 225 | 107 | 52.5 |
| | 2 | 3 | 107 | 84 | 62.5 |
| | 3 | 3 | 84 | 80 | 64.5 |
| 1.33 gal/ $(ft)^2$ (day) | 1 | 6 | 161 | 33 | 79.5 |
| | 2 | 3 | 33 | 28 | 82.5 |
| | 3 | 3 | 28 | 27 | 83.2 |

## New York City, New York (Reference 6)

These tests were conducted with municipal primary effluent at 1.0 to 1.6 gal./$(ft)^2$(day), a temperature range of 62° to 78°F and 3-ft diameter disks rotated at 10 rpm.

| Para-meter | No.of sam-ples | In-fiu-ent | Stage number 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| BOD, mg/1 | 33 | 124 | 82 | 59 | 44 | 28 | 19 | 17 | 14 | 12 | 9 | 9 |
| COD, mg/1 | 33 | 303 | 220 | 174 | 152 | 121 | 103 | 94 | 85 | 81 | 73 | 64 |
| SS, mg/1 | 33 | 107 | 69 | 47 | 44 | 31 | 20 | 16 | 14 | 13 | 12 | 9 |
| NH -N, mg/1 | 31 | 13 | 14.2 | 14.0 | 14.4 | 3.6 | 13.2 | 12.8 | 11.0 | 8.9 | 6.9 | 5.7 |
| $NO_2$+$NO_3$-N mg/1 | 27 | -- | -- | -- | -- | -- | 1.0 | 2.2 | 4.3 | 6.7 | 8.6 | 10.4 |

## SUMMARY

The following are advantages claimed for the rotating disk biological treatment process:

(1) Operation is extremely simple and does not require a high degree of operator experience.
(2) Maintenance is very low.
(3) Operating costs, particularly power costs, are lower than for other biological treatment systems.
(4) Rotating disks can readily handle any variations normally encountered in municipal sewage flows and quality.
(5) Nuisance odors are almost eliminated, as are trickling filter flies.
(6) Rotating disks are flexible and can provide additional levels of treatment by the simple addition of unit components.
(7) Rotating disks are reputed to be quick to install and start up.
(8) Rotating disks are reputed to produce a thick sludge that settles much more rapidly and completely than activated sludge, allowing shallower secondary clarifiers and higher surface loading rates.

Potential disadvantages for the rotating disk biological treatment process appear to be as follows:

(1) Construction costs are substantially higher than for other biological treatment processes.
(2) Without equalization tanks, the rotating disk biomass could be shocked by sudden surges of toxic wastes, to a greater extent than a completely mixed activated sludge system.
(3) Rotating disks should probably receive a lower hydraulic loading rate than that optimistically stated by the manufacturers.
(4) Rotating disks must be substantially oversized to handle influent waters of less than 55°F temperature.
(5) Due to temperature susceptibility, rotating disks should be covered in northern latitudes.
(6) Nitrification can be accomplished easily, but at substantial capital cost, by adding units to lower the hydraulic loading rate.
(7) A pilot plant should be tested on the proposed waste-stream in order to measure the effects of temperature, waste load and plant configuration. This is necessary primarily because the process is so new in this country, but also due to the high capital cost penalties of misjudgement in process efficiency.

## Granby Design Criteria

The rotating disk process designed for the Granby facility had been sized with seasonal loadings in mind. While wastewater flows during the summer months were expected to be 1.5 million gallons per day, they were expected to be only 750,000 gpd during the winter months. Hydraulic surface loading to the rotating disks during the summer would be 1.5 gal./(ft)$^2$(day) for an anticipated 93 percent overall $BOD_5$ removal from an influent level of 200 mg/ℓ. The previously presented operating results indicate that this is a marginally effective loading rate for ammonium nitrogen removal and that the design goal of 1.5 mg/ℓ effluent ammonium nitrogen from an assumed influent concentration of 35 mg/ℓ may not always be reached. Pilot plant verification of expected rotating disk performance would be an appropriate safety measure prior to detailed plant design.

Winter wastewater flows were estimated to produce a hydraulic loading of 0.75 gal./(ft)$^2$(day). Winter wastewater temperatures have been measured at 5°C [40°F] compared to summer temperatures of 20°C [68°F]. The lower biological process efficiency obtained at low temperatures would be offset by the doubled surface loading rate, and $BOD_5$ removals should remain equivalent. However, there exists the possibility that ammonium nitrogen removal would deteriorate at the low temperatures. If the Granby service area population should become substantially higher during the winter season than 50 percent of the summer season population, the expected hydraulic and biological buffering capacity of the plant would be reduced and pollutant removal efficiencies would drop.

# REFERENCES FOR APPENDIX D

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D-5. "Rotating Biological Contactors Following Anaerobic Lagoons," Chittenden, J.A. and Wells, W.J., Jr., Journal WPCF, 43, Publication No. 5, p. 746 (May 1971).

D-6. "Rotating Disks with Biological Growths Prepare Wastewater for Disposal or Reuse," Torpey, Wilbur N. et al, Journal WPCF, 43, Publication No. 11, p. 2181 (November 1971).

# APPENDIX E

## LAND APPLICATION OF PRETREATED EFFLUENT

This appendix is intended to provide general information regarding land application of pretreated effluent. More detailed information can be found in the references. In the event that a land application alternative is selected, more thorough site analysis should be conducted to determine suitability and site-specific characteristics for the implementation of such a program. Table E-1 presents information sources and needs for land applications (Reference E-1).

### INTRODUCTION

Land application of wastewater is practiced in many communities in order to prevent stream pollution and the waste of nutrient resources, both of which result from effluent discharge into streams. A basic premise of land application is that sewage wastes are considered not as refuse but as useful resources. The primary environmental concern with land application is the protection of groundwater quality. Wastewater applied to land surfaces is taken up by plants, lost to the air by evaporation, percolated through the soil to the groundwater supply, and lost to surface runoff.

In general, benefits from land application of sewage effluents include soil improvement, increased vegetative growth, added irrigation water, groundwater recharge, amelioration of disturbed unproductive lands, enhancement of watersheds and protection of vital natural resources (Reference E-2). Land application systems must be designed to provide protection for 1) surface and groundwater supplies, from pollutants and pathogens; 2) soils,from excessive nitrogen enrichment, the buildup of trace elements or heavy metals, and contamination with pathogens; 3) vegetation, from direct pollution of plant surfaces and the buildup of trace elements or heavy metals into harmful accumulations in plant tissue; and 4) animals feeding in treated areas, as well as people against direct contact with wastes (Reference E-3).

Four general classes of vegetation that may be considered for land application are 1) perennials (forage or fruit crops), 2) annuals (field crops), 3) landscape vegetation and 4) forest vegetation. Land application on forest land and crop land is discussed in detail below.

Few soils are inherently unsuitable for land application. Almost all negative effects resulting from land application arise from too heavy or too frequent applications. Overloading some aspect of the assimilation or utilization processes is the cause for failure in any malfunctioning land disposal system (Reference E-4).

## TABLE E-1

## INFORMATION NEEDS AND SOURCES FOR LAND APPLICATION OF WASTEWATER

| | INFORMATION SOURCE | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| INFORMATION NEEDS | Consultants | Municipal/Community Planning | Chamber of Commerce | NOAA, U.S. Weather Station | Library | Agricultural Extension Service | County Planning | Public Health | Assessor | U.S. Soil Conservation Service | Environmental Protection and/or Public Health | Historical Society | State Geological Survey | State Div. or Dept. of Water Resources | State University Extension Specialists | State Planning Office | Corps of Engineers | U.S. Forest Service | U.S. Geological Survey | USDA, Agricultural Research Service | U.S. Environmental Protection Agency | Planning Agency (COG, River Basin Resource Management Districts) |
| Climatic Data | | | | o | | o | | | | | | | | | o | | | | | | | |
| Soil Classification - Mapping | o | o | | | | | o | | | o | | | | | | | | | | | | |
| Soil Infiltration-Permeability | o | | | | | o | | | | o | | | | | o | | | | | o | | |
| Soil Depth 0 - 5 Feet | | | | | | | | | | o | | | | | | | | | | | | |
| Soil Drainage & Water Table < 5 Feet | | | | | | | | | | o | | | | | | | | | | | | |
| Soil Properties (Chemical & Physical) | o | | | | | o | | | | o | | | | | o | | | | | | | |
| Agricultural Land Use Capability | o | o | | | | o | o | | | o | | | | | | | | | | | | |
| Depth to Bedrock | | | | | | | | | | o | | | o | | | | | | o | | | |
| Unconsolidated Materials | | | | | | | | | | | | | o | | | | | | o | | | |
| Bedrock Type & Structural Characteristics | | | | | | | | | | | | | o | | | | | | o | | | |
| Jointing & Permeability of Rock | o | | | | | | | | | | | | o | o | | | | | o | | | |
| Rock Outcrops | | | | | | | | | | o | | | o | | | | | | o | | | |
| Surface Slope, Categories (ex. 0 - 3%) | | | | | | | | | | o | | | | | | | | | o | | | |
| Flood Plain, Flood Hazard | o | o | | | | | o | | | | | | | o | | | o | | o | | | |
| Streamflows | | | | | | | | | | | | | | o | | | | | o | | | o |
| Ground Water Yield | o | | | | | | | | | | | | o | o | | | | | o | | | o |
| Ground Water Elevation & Contours | o | | | | | | | | | | | | o | o | | | | | o | | | |
| Ground Water Aquifers | o | | | | | | o | | | | | | o | o | | | | | o | | | o |
| Irrigation Methods | o | | | | | o | | | | o | | | | | o | | | | | o | | |
| Crops | o | | | | | o | | | | o | | | | | o | | | o | | o | | |
| Interpretation of Soil Suitability | o | | | | | o | | | | o | | | | | o | | | | | o | | |
| Interpretation of Ground Water | o | | | | | | | | | | | | o | o | | | | | o | | | |
| Land Use | | o | | | | | o | | o | | | | | | | o | | | | | | o |
| Land Values | o | o | o | | | o | o | | o | | | | | | | | | | | | | o |
| Guidelines for Land Application | o | | | | | | | o | | | o | | | | | | o | | | | o | |
| Sensitive Environmental Areas | o | o | | | | | o | | | | o | o | | | | o | | | | | o | o |
| Socioeconomic Factors | o | o | o | | | | o | | o | | | | | | | o | | | | | | o |
| Institutions (any organization) | | | o | | o | | o | | | | | | | o | | o | | | | | | o |
| Aesthetics | | o | | | o | | o | | | | | | | | | | | | | | | |
| Biota | o | o | | | o | | o | | | | | | | | | | | | | | | o |

Source: Design Seminar for Land Treatment of Municipal Wastewater Effluents.

Different techniques of land application of effluent are utilized, depending on the objectives, site suitability, climatic factors and wastewater characteristics. Table E-2 presents some of the factors to be considered in selecting one or more application techniques. The spray irrigation process has been evaluated to have fair results in cold climates with a short growing season, acceptable for forest irrigation and marginal for cropland irrigation (Reference E-6). The length of the growing season is generally defined as the period (number of days) between the average date of last spring frost and first fall frost. A frost-free season of less than 125 days is an effective limitation to the production of most crops. Land application is possible at low temperatures if the wastewater does not freeze in distribution or spraying equipment. Little purification occurs at temperatures near or below freezing, and the effluent may freeze into mounds of ice at points of application, possibly harming the vegetation (Reference E-7).

During irrigation (particularly with high-rate irrigation techniques), effluent applied when the ground is frozen runs off directly to surface waters. High-rate irrigation may keep the soil from freezing when air temperature is a few degrees below the freezing point. For the infiltration-percolation process, applications of warm effluent may keep the soil from freezing under all but the most severe winter conditions. This process can extend the application time appreciably and is used successfully in extreme winter conditions in Idaho and Minnesota (Reference E-1).

## SITE CONSIDERATIONS

### Topography

The major topographic concern is the steepness of slope. On sloping lands, the rate of liquid effluent application should not exceed the soil infiltration capacity and percolation rate. Forested hillsides with controlled runoff might be highly efficient for land application, however. Flat or depressional areas are subject to ponding if the soils are slowly permeable or presaturated (Reference E-4). Topography is the limiting factor generally where low water infiltration into the soil can result in runoff and possibly soil erosion.

### Soils

In general, well-drained, loamy soils are preferable for the irrigation process (Reference E-6), although soils which are shallow, slowly permeable and underlain by impervious clay subsoil can be used (Reference E-8). The minimum depth to the groundwater table should be 1.5 m.(5 ft.), although lesser depths may be acceptable with underdrains or subsurface drainage systems (Reference E-6). Table E-3 presents site selection factors and criteria relating to soil and groundwater conditions.

## TABLE E-2

## FOUR LAND APPLICATION PROCESSES FOR TREATMENT OF MUNICIPAL WASTEWATER

| | Annual Loading Acre Ft/Ac/Yr | Net Irrigated Land Area Requirement for 1-MGD Flow | Objective | Suitable Soils | Dispersal of Applied Water | Impact on Quality of Applied Water |
|---|---|---|---|---|---|---|
| Overland Flow | 5 to 25 | 45 to 225 ac plus buffer areas, etc. | Maximize water treatment. Crop is incidental. | Slow permeability and/or high water table. | Most to surface runoff. Some to evapotranspiration and ground water. | BOD and SS greatly reduced. Nutrients reduced by fixation and crop growth. TDS increased some. |
| Irrigation(1) | <1 to >5 | <225 to >1,100 ac plus buffer areas, etc. | Maximize agricultural production. | Almost all soils suitable for irrigated agriculture. | Most to evapotranspiration. Some to ground water; little or no runoff. | BOD and SS removed. Most nutrients consumed in crop or fixed. TDS greatly increased. |
| High-rate(2) Irrigation | 1 to >10 | <110 to 1,100 ac plus buffer areas, etc. | Maximize water treatment by percolation through the soil-crop system with crop production as a side benefit. | More permeable soils suitable for irrigated agriculture; may use soils marginal because of coarse texture. | Evapotranspiration and ground water; little or no runoff. | BOD and SS mostly removed. Nutrients removed in crop or fixed. TDS increased by evapotranspiration and leaching. |
| Infiltration-(3) Percolation | 11 to 500 | 2 to 100 ac plus buffer areas, etc. | Recharge filter water or ground water; crop may be grown with little benefit. | Highly permeable sands and gravels. | Most to ground water some evapotranspiration; no runoff. | BOD and SS reduced. Some nutrient removal by soil. TDS may increase because of leaching. |

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(1) This approximates Alternative 5.

(2) This approximates land disposal, as presented in Alternative 4.

(3) The storage ponds under alternatives 4 and 5, if unlined, can serve partially as percolation ponds, especially if a rotation scheme is adopted to maintain high permeability.

Source: Comparative Study of Wastewater Treatment, City of Boulder.

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## Table E-3. SITE SELECTION FACTORS AND CRITERIA FOR EFFLUENT IRRIGATION

| Factor | Criterion |
|---|---|
| Soil type | Loamy soils are preferable but most soils from sands to clays are acceptable. |
| Soil drainability | Well drained soil is preferable; consult experienced agricultural advisors. |
| Soil depth | Uniformly 1.5 - 1.8 m [5 - 6 ft] or more throughout sites is preferred. |
| Depth to groundwater | Minimum of 1.5 m [5 ft] is preferred. Drainage to obtain this minimum may be required. |
| Groundwater control | May be necessary to ensure renovation if water table is less than 3 m [10 ft] from surface. |
| Groundwater movement | Velocity and direction must be determined. |
| Slopes | Up to 15 percent are acceptable with or without terracing. |
| Underground formations | Should be mapped and analyzed with respect to interference with groundwater or percolating water movement. |
| Isolation | Moderate isolation from public is preferable, degree dependent on wastewater characteristics, method of application and crop. |
| Distance from source of wastewater | A matter of economics. |

Source: *Wastewater Treatment and Reuse by Land Application.*

Soil properties at the root zone determine the suitable loading rate (Reference E-1). Physical soil characteristics such as porosity, structure, texture (grain-size distribution) and mineralogy should be considered. Soil filterability is a property that determines how efficiently a soil can act as a physical filter of suspended particles and pathogenic organisms. Permeable soils of intermediate texture with enough colloidal content to trap particulates are generally the best filters. Soils that are least suitable for land application include those that are 1) extremely fine-textured, 2) extremely coarse-textured, such as sands and gravels, 3) very shallow, 4) wet or undrained, 5) frozen and 6) solonetz and others that are sodium saturated (Reference E-4).

## Effluent Loading Constraints

The effluent loading rate may be limited by any of several factors, such as 1) the infiltration capacity of the soil; 2) the permeability of the root zone and underlying geologic materials; 3) soil and plant capacity to remove major plant nutrients (nitrogen and phosphorus); 4) the soil capacity to filter and remove suspended solids and organic and inorganic compounds; and 5) climatic influences such as precipitation, evapotranspiration and growing season (Reference E-1).

The addition to the soil of nitrogen in wastewater effluent is a matter of concern. In general, nitrogen that is not taken up by plants or is not denitrified can leach through the soil profile and contaminate the groundwater supply. The ability of different kinds of crops to remove nitrogen is shown in Table E-4. There is little hazard of nitrogen toxicity to crops when typical municipal effluent is applied to land (Reference E-1). Monitoring of nitrogen concentrations is essential because nitrogen removal is sensitive to a variety of environmental conditions. Groundwater contamination may be a problem when high loading rates are applied to crops with low nutrient uptake ability. Application of effluent to lands that are harvested would entail less nitrogen build-up than to lands that are not harvested or that have nitrates returned to them in the form of animal wastes.

Climatic factors affect the timing of effluent application, as well as the technique of application. Maximum effluent loading is conducted during the active growing season. Irrigation can also be conducted during months when evapotranspiration is greater than precipitation. In Granby, for example, the growing season is only two months long (June and July), while evapotranspiration exceeds precipitation for six months.

## Pathogens

Microorganisms, primarily bacteria, are usually present in wastewater, although most of them are removed by conventional treatment. The soil is quite efficient in the removal of bacteria and some viruses through the processes of filtration and adsorption. Pathogens

## Table E-4. REPORTED NUTRIENT REMOVAL BY FORAGE CROPS, FIELD CROPS AND FOREST CROPS

| Crops | Nitrogen uptake kg/ha/yr | Nitrogen uptake [lbs/ac/yr] |
|---|---|---|
| **Forage crops** | | |
| Coastal Bermuda grass | 538-672 | 480-600 |
| Reed canary grass | 253-402 | 226-359 |
| Fescue | 308 | 275 |
| Alfalfa[a] | 174-246 | 155-220 |
| Sweet clover[a] | 177 | 158 |
| Red clover[a] | 86-141 | 77-126 |
| Lespedeza hay | 146 | 130 |
| **Field crops** | | |
| Corn | 174 | 155 |
| Soy beans[a] | 105-127 | 94-113 |
| Irish potatoes | 121 | 108 |
| Cotton | 74-112 | 66-100 |
| Milo maize | 91 | 81 |
| Wheat | 56-85 | 50-76 |
| Sweet potatoes | 84 | 75 |
| Sugar beets | 82 | 73 |
| Barley | 71 | 63 |
| Oats | 59 | 53 |
| **Forest crops[b]** | | |
| Young deciduous (up to 5 years) | 112 | 100 |
| Young evergreen (up to 5 years) | 67 | 60 |
| Medium and mature deciduous | 34-56 | 30-50 |
| Medium and mature evergreen | 22-34 | 20-30 |

[a] Legumes obtain a substantial part of their nitrogen requirements from the air.

[b] Estimated.

Source: Design Seminar for Land Treatment of Municipal Wastewater Effluents.

can be transmitted by aerosols (microscopic droplets). Aerosol travel and pathogen survival rate are dependent on several factors, including wind, temperature and humidity. Safety measures that may limit aerosol transmission include buffer zones around the irrigated area, sprinklers that spray laterally or downward with low nozzle pressure, and cessation of spraying or spraying only interior plots during high winds (Reference E-6). There is no documented evidence of harm to crops, humans or animals resulting from irrigation with effluent (Reference E-9).

### Water Rights

Land application on presently unirrigated land would result in increased evaporation (consumptive use) which would decrease streamflows and may violate downstream water rights (Reference E-1). Wright and Toren state, however, that the Colorado Water Law Appropriation Doctrine "is very flexible and permits almost anything to be devised as long as adverse material injury is not caused to owners of other vested water right appropriations." (Reference E-10).

### Open Space

The implementation of a land application system could lead to the preservation of open space areas in regions where pressures for future development are expected.

## LAND DISPOSAL ON FORESTS

Utilization of forest areas as disposal sites has several practical aspects. Forest stands in the Granby planning area occur widely within BLM land, Arapaho National Forest and private lands and are generally remote from areas of human concentration. Forest areas generally have a lower soil fertility than croplands and a higher water uptake potential. The timber resource also has a long cropping period and yields a non-ingested commercial product. Well-established forests also remove more water from soils through evapotranspiration than do other vegetation. Soils supporting thickly-forested areas are less subject to freezing than open croplands and thus may allow a longer irrigation period.

Forest systems compatible with irrigation using wastewater are those containing tree species which are 1) water tolerant, 2) capable of rapid uptake and utilization of nutrients, and 3) amenable to harvest operations such as clear cutting or clean harvesting for maximum use and removal of nutrients (Reference E-3). Lodgepole pine, which is the predominant forest species in the study area, more than adequately satisfies two of these criteria: it is water tolerant, and it is amenable to most harvesting systems, especially clear cutting. The capability of lodgepole pine to take up nutrients rapidly is limited by the slow growth of the species. Although some studies have shown that forested areas can reduce nitrogen concentrations in the soil (Reference E-12), forests are generally much less efficient than crops in the removal of nitrogen. Thus, to apply effluents to forests, the nitrogen limitation will have to be lower than that for agricultural crops (Reference E-1).

## CROPLAND IRRIGATION

Proper crop selection depends on 1) relationship to critical loading parameter (determined by wastewater and site characteristics), 2) public health regulations, 3) ease of cultivation and harvesting, and 4) the length of the growing season. Maximum crop yields are obtained by the use of indigenous species (Reference E-6).

Perennial grasses appear to be the most suitable for effluent irrigation, primarily because they can remove nitrogen to low concentrations (see Table E-4). Perennial grasses have fibrous root systems, are sod forming (this aids in erosion control and provides for high infiltration rates), are tolerant of a wide range of ecological conditions, have a long period of growth and have a high uptake of nutrients (Reference E-11).

In general, the effects of effluent irrigation on vegetation are usually beneficial. Most essential plant nutrients are found in wastewater and should stimulate plant growth. Toxic levels of certain elements in the soil, which may adversely affect crop growth, must be evaluated. Excess hydraulic loadings or poor soil aeration may also be harmful to vegetative growth (Reference E-6). In Granby, due to a lack of industrial discharges, it is expected that wastewaters are essentially free of toxic levels of heavy metals.

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EPA-430/9-75-013
OCTOBER 1975

# ALTERNATIVE WASTE MANAGEMENT TECHNIQUES FOR BEST PRACTICABLE WASTE TREATMENT.

U.S. ENVIRONMENTAL PROTECTION AGENCY
Office of Water Program Operations
Washington, D.C. 20460

Appendix F

MCD-13

# ALTERNATIVE WASTE MANAGEMENT TECHNIQUES FOR BEST PRACTICABLE WASTE TREATMENT

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# CHAPTER I. INTRODUCTION

This document is intended to provide information pursuant to Section 304(d)(2) of the Federal Water Pollution Control Act Amendments of 1972 (the Act) on practicable techniques by which publicly-owned treatment works can restore and maintain the integrity of the Nation's waters. The document identifies the currently known techniques, summarizes the technology, and includes an extensive bibliography (Appendix A).

## A. Statutory Requirements

The Act (P. L. 92-500) refers to best practicable waste treatment technology (BPWTT), or to the manner in which it is to be determined, in three key sections.

Under Section 304(d)(2), which imposes the earliest deadline ("within nine months of the enactment of this title, and from time to time thereafter"), EPA is to publish:

> "Information on alternative waste treatment management techniques and systems available to implement Section 201 of this Act."

Section 201, the only section where the phrase "best practicable waste treatment technology" actually appears, declares that:

> "Waste treatment management plans and practices shall provide for the application of the best practicable waste treatment technology before any discharge into receiving waters, including reclaiming and recycling of water, and confined disposal of pollutants so they will not migrate to cause water or other environmental pollution and shall provide for consideration of advanced waste treatment technques."

To realize this purpose, Section 201(g)(2)(A) stipulates that:

> "The Administrator shall not make grants from funds authorized for any fiscal year beginning after June 30, 1974, . . . unless . . . alternative waste management techniques have been studied and evaluated and the works proposed for grant assistance will provide for the application of the best practicable waste treatment technology over the life of the works consistent with the purposes of this title."

Funds for FY 1975, the first year affected by the BPWTT requirement, became available January 1, 1974.

Under Section 301(b)(2)(B) the requirements which pertain to publicly-owned treatment works (POTW's) receiving Federal funds are generalized to all POTW's for 1983:

> **"In order to carry out the objective of this Act (to restore and maintain the chemical, physical, and biological integrity of the Nation's waters) there shall be achieved . . . not later than July 1, 1983, compliance by all publicly owned treatment works with the requirements set forth in Section 201(g)(2)(A)** of this Act."

In summary, the information developed under Section 304, which is first used for funding purposes under Section 201, is eventually used for enforcement purposes under Section 301. This is accomplished through National Pollutant Discharge Elimination System (NPDES) permits issued under Section 402, which allow the discharge of pollutants, provided the discharge meets all applicable requirements of the Act (in this case, of Section 301).

## B. Legislative History

The earliest guidance on Sections 201, 301, or 304 is contained in the Senate Committee Report's comments on Section 201. There is a strong emphasis on land disposal, reflecting the original version of the legislation. It required land treatment as BPWTT except where a municipality could prove the superiority of another technique. In a different vein, the Committee also warned against reliance on conventional dry-weather waste treatment technology. The Committee noted that in many places water quality objectives will remain beyond reach until attention is given to the treatment of storm water runoff and combined sewer overflows.

The House Committee Report on Section 201 is in many respects a rejoinder to the Senate report. The House Committee warned against reliance on any one treatment technique as a panacea. Rather, it listed three standard alternative techniques for consideration: treatment and discharge to receiving water, treatment and reuse, and spray-irrigation or other land disposal methods. In its comments on Section 304, however, the House Committee did urge that the information EPA publishes on alternative waste management techniques emphasize land disposal. Finally, under Section 201, the House stressed that any determination of BPWTT should consider possible trade-offs between air, land, and water disposal of pollutants.

### C. Synopsis

The information contained in this document will guide policy-owned treatment works in selecting waste treatment alternatives to restore and maintain the integrity of the Nation's waters.

Chapter II specifies the criteria to meet best practicable waste treatment for the broad categories of treatment and discharge into navigable waters, land application and utilization practices, and reuse of treated wastewater. Criteria less stringent than those established in Chapter II are not acceptable. Criteria which are more stringent must be justified or be pursuant to more stringent State and local law.

Chapters III, IV, and V develop the rationale behind the criteria as well as present information pertaining to acceptable alternative waste management techniques. These chapters are not intended to include all possible approaches that are or might become practicable. Therefore, techniques and technologies not discussed in this document can be employed to achieve the criteria in the most cost-effective manner.

# CHAPTER II:
# CRITERIA FOR BEST PRACTICABLE WASTE TREATMENT

Applicants for construction grant funds authorized by Section 201 of the Act must have evaluated alternative waste treatment management techniques and selected the technique which will provide for the application of best practicable waste treatment technology. Alternatives must be considered in three broad categories: treatment and discharge into navigable waters, land application and utilization practices, and reuse of treated wastewater. An alternative is "best practicable" if it is determined to be cost-effective in accordance with the procedures set forth in 40 CFR Part 35 (Appendix B to this document) and if it will meet the criteria set forth below.

### (A) Alternatives Employing Treatment and Discharge into Navigable Waters

Publicly-owned treatment works employing treatment and discharge into navigable waters shall, as a minimum, achieve the degree of treatment attainable by the application of secondary treatment as defined in 40 CFR 133 (Appendix C). Requirements for additional treatment, or alternate management techniques, will depend on several factors, including availability of cost-effective technology, cost and the specific characteristics of the affected receiving water body.

### (B) Alternatives Employing Land Application Techniques and Land Utilization Practices

Publicly-owned treatment works employing land application techniques and land utilization practices which result in a discharge to navigable waters shall meet the criteria for treatment and discharge under Paragraph (A) above.

The ground water resulting from the land application of wastewater, including the affected native groundwater, shall meet the following criteria:

*Case I:* The ground water can potentially be used for drinking water supply.

(1) The standards for chemical quality and pesticides specified in the EPA Manual for Evaluating Public Drinking Water Supplies (Appendix D) for drinking water supply sources should not be exceeded except as indicated below (See Note 1).

(2) If the existing concentration of a parameter exceeds the standards for chemical quality or pesticides, there should not be an increase in the concentration of that parameter due to land application of wastewater.

*Case II:* The ground water is used for drinking water supply.

(1) The criteria for Case I should be met.

(2) The bacteriological standards for drink-

ing water supply sources specified in the EPA Manual for Evaluating Drinking Water Supplies (Appendix D) should not be exceeded (See Note 1).

*Case III:* Uses other than drinking water supply.

(1) Ground water criteria should be established by the Regional Administrator based on the present or potential use of the ground water.

The Regional Administrator in conjunction with the appropriate State officials and the grantee shall determine on a site-by-site basis the areas in the vicinity of a specific land application site where the criteria in Case I, II, and III shall apply. Specifically determined shall be the monitoring requirements appropriate for the project site. This determination shall be made with the objective of protecting the ground water for use as a drinking water supply and/or other designated uses as appropriate and preventing irrevocable damage to ground water. Requirements shall include provisions for monitoring the effect on the native ground water.

**(C) Alternatives Employing Reuse**

The total quantity of any pollutant in the effluent from a reuse project which is directly attributable to the effluent from a publicly-owned treatment works shall not exceed that which would have been allowed under Paragraphs (A) and (B) above.

**NOTE 1**

Any chemical, pesticides, or bacteriological standards for drinking water supply sources hereafter issued by EPA shall automatically apply in lieu of the standards in the EPA Manual for Evaluating Public Drinking Water Supplies.

## CHAPTER III:
## WASTE MANAGEMENT TECHNIQUES INVOLVING LAND APPLICATION OR LAND UTILIZATION

Land application systems can be classified with respect to the ultimate disposition of the applied wastewater: (1) percolation of wastewater through the soil until it becomes part of the permanent aquifer and (2) collection of land applied wastewater either by means of underdrain systems or as a result of surface runoff. Percolation systems which result in permanent ground water must meet the ground water quality criteria established for such systems. Land application systems which collect the applied wastewater in underdrain systems and/or result in surface runoff must comply with the wastewater treatment and discharge criteria if the collected wastewater is discharged to navigable waters.

Three different cases can be identified for percolation of wastewater through the soil: (1) the receiving ground water has the potential for use as a drinking water supply; (2) the receiving ground water is used as a drinking water supply; and (3) the receiving ground water has other uses. Achieving best practicable technology for these cases requires meeting the applicable ground water criteria. The specific ground water criteria are determined on the basis of the level of ground water protection necessary.

Where the receiving ground water has the potential to be used as a drinking water supply, the bacteriological criteria for drinking water supplies (Appendix D) can be met by standard water treatment practice at a reasonable cost. However, because the water treatment technology available for the removal of chemical pollutants and pesticides is not widely practiced and is costly, the chemical and pesticide criteria (Appendix D) should apply when land application is considered.

In the case of receiving ground water which is already being used as a public or private water supply, protection of the ground water from pathogenic pollution is necessary in addition to meeting chemical and pesticides criteria. The bacteriological criteria in this case should be consistent with the level of treatment received by the ground water prior to public use. If, for example, a number of existing private wells use the ground water resulting from the land application system, the bacteriological standards for ground water usable without treatment shall apply.

When the ground water is not being used as a water supply because of contamination and does not have the potential through treatment to be used as a drinking water supply, the Regional Administrator will determine the applicable ground water criteria on a case-by-case basis. In making these determinations, the Regional Administrator will consider localized conditions as well as the future intended uses of the ground water.

For all of the above categories, if the existing concentrations of any pollutant parameter are at a higher level in the receiving ground water than allowed by the applicable criteria, further increases in concentration of that parameter shall not be allowed. Furthermore, any public drinking water standards for raw or untreated drinking water supplies that are hereafter issued by EPA to prescribe maximum allowable limits or permissible concentrations of chemicals, pesticides, bacteriological quality, or other parameters will apply as required.

Grant applications involving land application techniques will be evaluated with the procedures established in an EPA Technical Bulletin entitled "Evaluation of Land Application Systems, EPA-430/9-75-001." The specific engineering details and monitoring requirements are the subject of that manual. The following information is presented for informational purposes and as design criteria.

## A. Land Application Techniques

The following discussion is largely based on "Wastewater Treatment and Reuse by Land Application," written by Charles Pound and Ronald Crites of Metcalf and Eddy, Inc. under contract to EPA.

Irrigation, overland flow, and infiltration-percolation, the three basic approaches to land application, are shown schematically in Figure 1. Their major characteristics are listed in Tables 1 and 2 and Figure 2. In all three approaches wastewater may be applied by spraying or other surface application techniques, such as leaching fields and evaporation ponds.

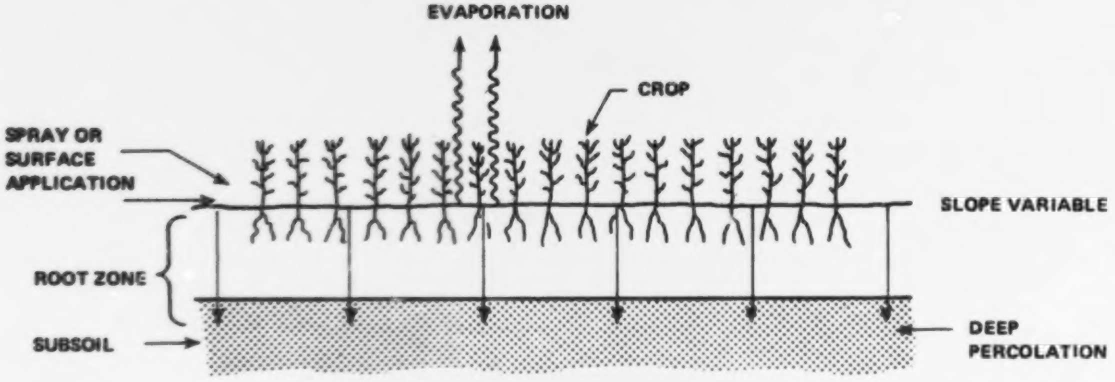
Municipal wastewater, usually pretreated to some extent, has been applied to land mainly by irrigation and infiltration. Recently, municipal installations have begun to experiment with overland flow. Industrial wastewater, generally screened or settled, has been applied using all three approaches, with the choice usually dependent on the type of soil nearby.

### Irrigation

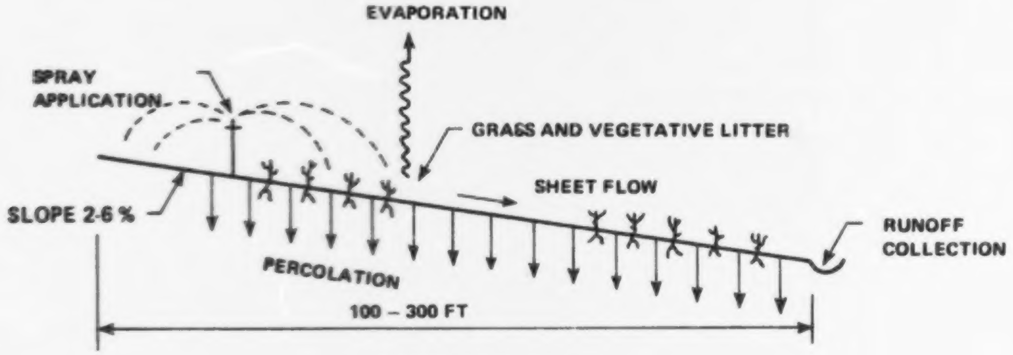
Irrigation is the most widely used type of land application; between 100 and 450 U. S. communities practice this approach. The controlling

Table 1. COMPARATIVE CHARACTERISTICS OF LAND-APPLICATION APPROACHES

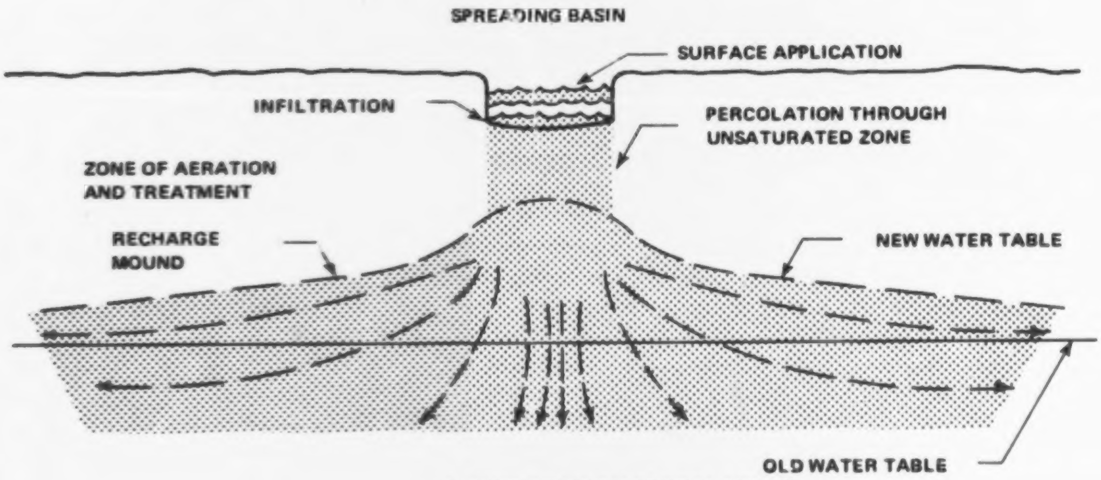
| Factor | Type of Approach: Irrigation | Overland Flow | Infiltration-percolation |
|---|---|---|---|
| Liquid-loading rate | 0.5 to 4 in/wk | 2 to 5.5 in/wk | 0.3 to 1.0 ft/wk |
| Annual application | 2 to 8 ft/yr | 8 to 24 ft/yr | 18 to 500 ft/yr |
| Land required for 1-MGD flow | 62 to 560 acres plus buffer zones | 46 to 140 acres plus buffer zones | 2 to 62 acres plus buffer zones |
| Application techniques | Spray or surface | Usually spray | Usually surface |
| Soils | Moderately permeable soils with good productivity when irrigated | Slowly permeable soils such as clay loams and clay | Rapidly permeable soils such as sands, loamy sands, and sandy loams |
| Probability of influencing groundwater quality | Moderate | Slight | Certain |
| Needed depth to groundwater | About 5 ft | Undetermined | About 15 ft |
| Wastewater losses | Predominantly evaporation or deep percolation | Predominantly surface discharge but some evaporation and percolation | Percolation to groundwater |


EVAPORATION
CROP
SPRAY OR SURFACE APPLICATION
SLOPE VARIABLE
ROOT ZONE
SUBSOIL
DEEP PERCOLATION

a) IRRIGATION


EVAPORATION
SPRAY APPLICATION
GRASS AND VEGETATIVE LITTER
SHEET FLOW
SLOPE 2-6 %
RUNOFF COLLECTION
PERCOLATION
100 – 300 FT

b) OVERLAND FLOW


SPREADING BASIN
SURFACE APPLICATION
INFILTRATION
PERCOLATION THROUGH UNSATURATED ZONE
ZONE OF AERATION AND TREATMENT
RECHARGE MOUND
NEW WATER TABLE
OLD WATER TABLE

c) INFILTRATION-PERCOLATION

Figure 1. LAND APPLICATION APPROACHES

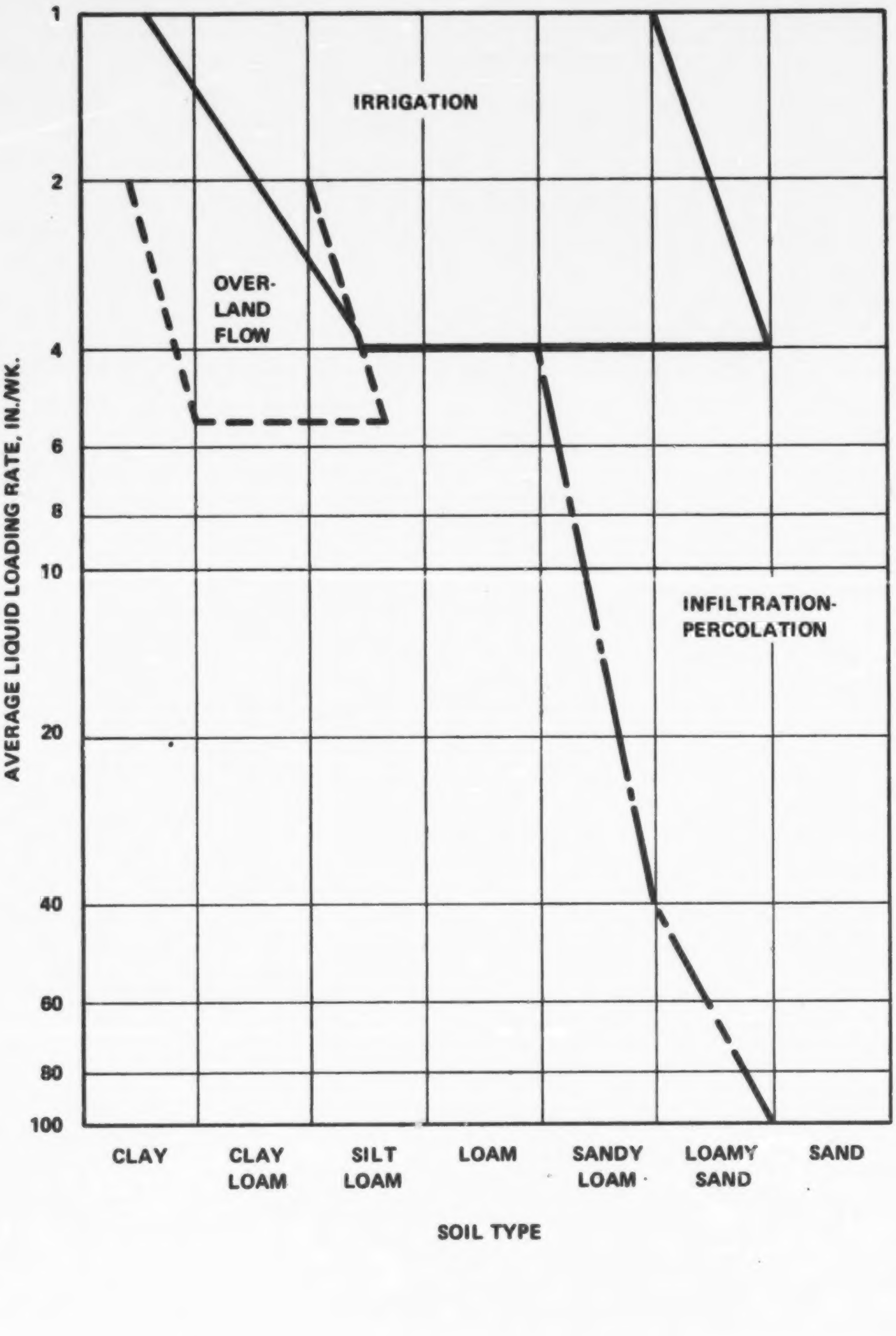


Figure 2. SOIL TYPE VERSUS LIQUID-LOADING RATES FOR DIFFERENT LAND-APPLICATION APPROACHES

### Table 2. COMPARISON OF POTENTIAL OBJECTIVES FOR LAND-APPLICATION APPROACHES FROM THE LITERATURE

| Objective | Type of Approach | | |
|---|---|---|---|
| | Irrigation | Overland Flow | Infiltration-percolation |
| Use as a treatment process with a recovery of treated water | Generally impractical | 50 to 60% recovery | Up to 90% recovery |
| Use for treatment beyond secondary: | | | |
| 1. For BOD and suspended solids removal | 90-99% | 90-99% | 90-99% |
| 2. For nitrogen removal | 85-90% | 70-90% | 0-80% |
| 3. For phosphorus removal | 80-99% | 50-60% | 70-95% |
| Use to grow crops for sale | Excellent | Fair | Poor |
| Use as direct recycle to the land | Complete | Partial | Complete |
| Use to recharge groundwater | 0-30% | 0-10% | Up to 90% |
| Use in cold climates | Fair[a] | --[b] | Excellent |

[a] Conflicting data—woods irrigation acceptable, cropland irrigation marginal.
[b] Insufficient data.

factors in this type of land application are site selection and design, methods of irrigation, loading rates, management and cropping practices, and the expected treatment or removal of wastewater constituents.

The major factors involved in site selection are type, drainability, and depth of soil; nature, variation of depth, and type of underground formation; topography; and considerations of public access to the land. Climate is as important as the land in the design and operation of irrigation systems. It is not a variable, however, because feasible sites must be within economic transmission distance of the source.

Table 3 lists major factors and generalized criteria for site selection. Soil drainability is perhaps the primary factor. Agricultural extension service advisers or adjacent farmers should be consulted about drainability of cropland, and university specialists should be consulted for forest or landscape irrigation. The drainability is important because, coupled with the type of crop or vegetation selected, it directly affects the liquid loading rate. The ideal is a moderately permeable soil capable of infiltrating approximately 2 inches per day or more on an intermittent basis. In general, soils ranging from clay loams to sandy loams are suitable for irrigation. Soil depth should be at least 2 feet of homogenous material and preferably 5 to 6 feet throughout the site. This depth is needed for extensive root development of some plants, as well as for wastewater treatment.

For crop irrigation, slopes are generally limited to about 10 percent or less, depending upon the type of farm equipment to be used. Heavily foliated hillsides up to 30 percent in slope have been spray-irrigated successfully.

A suitable site for wastewater irrigation would preferably be located in an area where contact between the public and the irrigation water and land is limited. However, this criterion is often impossible to meet in landscape irrigation.

Spray, ridge and furrow, and flood are three

## Table 3. SITE SELECTION FACTORS AND CRITERIA FOR IRRIGATION

| Factor | Criterion |
|---|---|
| Soil type | Loamy soils preferable, but most soils from sands to clays are acceptable |
| Soil drainability | Well-drained (more than 2 in./day) soil preferred; consult experienced agricultural advisers |
| Soil depth | Uniformly at least 5 to 6 ft throughout site |
| Depth to groundwater | Minimum of 5 ft at all times |
| Groundwater control | May be necessary to ensure treatment if water table is less than 10 ft from surface |
| Groundwater movement | Velocity and direction must be determined |
| Slopes | Up to 15% are acceptable with or without terracing |
| Underground formations | Should be mapped and analyzed with respect to interference with groundwater or percolating water movement |
| Isolation | Moderate isolation from public preferable, the degree depending on wastewater characteristics, method of application and crop |
| Distance from source of wastewater | Economics |

basic methods of irrigating. Spray irrigation may be accomplished using a variety of systems from portable to solid-set sprinklers. Ridge and furrow irrigation consists of applying water by gravity flow into furrows; relatively flat land is groomed into alternating ridges and furrows, with crops grown on the ridges. Flood irrigation is the inundation of land with several inches of water. The type of irrigation system used to maintain the specified ground water quality objectives depends on soil drainability, crop, topography, climate, and economics.

The important loading rates are liquid loading in terms of inches per week, and nitrogen loading in terms of pounds per acre per year. Organic loading rates are less important if an intermittent application schedule is followed. Liquid loadings should not exceed the infiltration capacity of the soil and may range from 0.5 to 4.2 inches per week depending on soil, crop, climate, and wastewater characteristics. Crop requirements generally range from 0.2 to 2.0 inches per week, although a specific crop's water needs will vary throughout the growing season. Typical liquid loadings are from 1.5 to 4.0 inches per week. Although wastewater irrigation rates have ranged up to 7 or 8 inches per week, a generalized division between irrigation and infiltration-percolation systems is 4 inches per week.

Nitrogen-loading rates have been calculated because of nitrate buildup in soils, underdrain waters, and ground waters. To minimize such buildup, the weight of total nitrogen applied in a year should not greatly exceed the weight removed by crop harvest. With loamy soils, the permissible liquid-loading rate will be the controlling factor in most cases; for more porous sandy soils the nitrogen-loading rate may be the controlling factor.

Crop selection can be based on several factors: high water and nutrient uptake, salt or boron tolerance, market value, or management requirements. Popular crop choices are grasses with high year-round uptakes of water and nitrogen and low maintenance requirements. A drying period ranging from several hours each day to several weeks is required to maintain aerobic soil conditions. The length of time depends upon the crop, the wastewater characteristics, the length of the application period, and the texture and drainage characteristics of the soil. A ratio of drying to wetting of about 3 or 4 to 1 should be considered a minimum.

Treatment of the wastewater often occurs after passage through the first 2 to 4 feet of soil. The extent of treatment is generally not monitored; when it is, however, removals are found to be on the order of from 20 to 99 percent for BOD, suspended solids, and bacteria. As irrigation soils are loamy with considerable organic matter, the heavy metals, phosphorus, and viruses have been found to be nearly completely removed by adsorption. Nitrogen is taken up by plant growth; if the crop is harvested, the removals can be on the order of 90 percent.

Wastewater irrigation has been shown to have a long, useful life, e. g., the systems at Cheyenne, Wyo., operating since 1881; at Fresno, Calif., since 1891; and at Bakersfield, Calif., since 1912.

Wastewater treatment is quite effective at direct recycling of pollutants to the land. Irrigation has had many positive effects on the environment, such as providing wildlife habitats when public access is properly managed. In general, irrigation is considered the most reliable approach to land application of wastewater.

Capital costs for irrigation include those for land, pretreatment, transmission, and distribution. Operating and maintenance costs are for labor, maintenance, and power. The direct economic benefits from irrigation can offset some of the operating costs. The information reported below provides an indication of the range of costs for existing systems and does not necessarily reflect the costs of meeting the BPWTT criteria for land application systems.

Land costs vary tremendously, but a typical current price is $500 per acre. Pretreatment costs for a 1-million-gallon-per-day (MGD) system range from 2.7 cents per 1,000 gallons for screening to 34.6 cents per 1,000 gallons for activated sludge. These costs are totals determined by adding amortized capital costs (25 years at 7 percent) to operating and maintenance costs. The figures are updated to January 1973.

Capital costs for spray irrigation for 10 Michigan sites in 1972 ranged from $1,000 to $5,000 per acre. Costs reported for cannery waste-disposal systems (in 1971) varied from $200 to $2,300 per acre. A cost (in 1967) for a 1-MGD system on 129 acres of $2,700 per acre was also reported; the amortized cost (20 years at 6 percent) was 10 cents per 1,000 gallons of wastewater treated.

For spray sites the reported costs were $800 per acre (in 1968) for the solid set system at Idaho Supreme; $1,500 per acre (in 1966) for golf course irrigation at Moulton-Niguel in Southern Calif.; and $140 per acre (in 1968) for a center pivot rig at Portales, N. M.

Reported operating and maintenance costs, including pretreatment, for six municipal systems varied from 2.7 to 11.6 cents per 1,000 gallons. The costs for six industrial-wastewater systems ranged from 7.3 to 23.9 cents per 1,000 gallons in 1972. The higher operating costs were for canneries operating on a seasonal basis. Estimated cost for spraying hardboard wastes is 5 cents per 1,000 gallons.

At the Mount Vernon Sanitary District in California, costs for a 1,000-acre ridge-and-furrow irrigation system (in 1956) were $75 per acre, including leveling, preparation, and fertilizing. Other plants reported ridge and furrow capital costs of $300 per acre for a Minnesota creamery (in 1950) and $2,000 per acre for a Wisconsin creamery (in 1954).

Operating and maintenance costs at Beardmore, Canada (in 1958) were 12.7 cents per 1,000 gallons. Costs at the Green Giant Co. cannery in Montgomery, Minn. (in 1953) were 22.2 cents per 1,000 gallons.

Provided that the land is relatively level, capital costs for flood irrigation will be less than for spray or ridge and furrow. Capital costs, however, were not reported in the literature. Operating and maintenance costs for flooding at Abilene, Tex., were 7 cents per 1,000 gallons and at Woodland, Calif., 4.2 cents. Both costs include pretreatment.

Cities using irrigation derive direct benefits in different ways. At Woodland, Calif., the city's land is leased for $23 per acre per year for summer irrigation; in addition, a duck club pays about $6 per acre per year for the same land for duck-hunting privileges in late fall. At Abilene, Tex., city land is leased for $12 per acre per year, and additional effluent is provided to adjacent farms. Pomona purchases treated wastewater from the Los Angeles County Sanitation Districts at $7 per acre-foot and sells it to various users at $5 to $22 per acre-foot. San Angelo, Tex. operates a 750-acre city farm at an annual profit of $30 per acre.

**Overland Flow**

In overland flow the land is sloping, the water runs off, and the crop is not always harvested.

Overland flow has been used for some time.

The method has been tried experimentally on municipal wastewater at Ada, Okla., but it has been more compledely developed for use in the United States on food-processing wastewater. The important factors in overland flow are site selection, design loadings, management practices, and treatment to be expected. If the runoff water is collected and discharged into a navigable water, it will have to meet the treatment and discharge criteria.

Soils suited to overland flow are clays and clay loams with limited drainability. The land should have a slope of between 2 and 6 percent, so that the wastewater will flow in a sheet over the ground surface. Grass is planted to provide a habitat for the bacteria which help purify the wastewater. As runoff is expected, suitable surface waters should be nearby to receive the discharge.

Because ground water will not likely be affected by overland flow, it is of minor concern in site selection. The ground water table should be deeper than 2 feet, however, so that the root zone is not waterlogged.

Even though climatic constraints have not been thoroughly tested, systems are being operated in Calif., Tex., Ohio, Pa., Ind., and Md. A system is being considered which will attempt to use overland flow when the ground is frozen. At Melbourne overland flow is used only during the mild winters when evaporation is low.

Overland flow systems are generally designed on the basis of liquid-loading rates, although an organic-loading or detention-time criterion might be developed in the future. The process is essentially biological, with a minimum contact time between bacteria and wastewater required for adequate treatment. Liquid-loading rates used in design have ranged from 2.5 to 5.5 inches per week, with a typical loading being 4 inches per week. At Ada the optimum loading has been around 4 inches per week, while at Melbourne it is 5.2 inches per week.

Management practices important in overland flow are maintaining the proper hydraulic loading cycle (periods of application followed by resting), maintaining an active biota and a growing grass, and monitoring the performance of the system. Hydraulic loading cycles have been found to range from 6 to 8 hours of spraying followed by 6 to 18 hours of drying. Periodic cutting of the grass with or without removal is important, but the effects on organic oxidation have not been fully demonstrated. Loading cycles must be monitored for maximum removal efficiencies.

Treatment of wastewater by overland flow is only slightly less complete than for irrigation. The overland flow systems at Melbourne and Ada (both using municipal wastewater) and at Paris, Tex. (using industrial wastewater) have been monitored to determine removal efficiencies. The results suggest BOD and suspended solids removals of from 95 to 99 percent, nitrogen removals of from 70 to 90 percent, and phosphorus removals of from 50 to 60 percent. Solids and organics are removed by biological oxidation of the solids as they pass through the vegetative litter. Nutrients are removed mainly by crop uptake. Other removal mechanisms for nutrients include biological uptake, denitrification, and fixation in the soil.

Less is known about the useful life of an overland flow system than about an irrigation system. The Melbourne system has been operating successfully for many years as a wintertime alternative to irrigation. The oldest operating system in this country, however, has been treating industrial wastewater for less than 20 years. Analysis of the literature suggests that an indefinite useful life may be possible if effective management continues.

Adverse environmental effects should be minimal. As a runoff flow is created, it must be stored, reused, or discharged to a surface watercourse. As infiltration into the soil is slight, the chances of affecting ground water quality are low.

Cost data on overland flow facilities are scarce because of the limited number of overland flow sites in operation. Capital costs include land, pretreatment, transmission, earthwork, distribution, and collection. Land costs are quite variable; even at the Paris site, they varied from $50 to $600 per acre for the 500 acres purchased. Pretreatment generally consists of screening. Transmission generally is by pumping.

Earthwork will vary with the original topography of the site. At Paris, the rolling land was regraded at a cost of $306 per acre for clearing, $108 per acre for grass cover, and $188 per acre for miscellaneous work. On the other hand, complete regrading of flat land to 2.5 percent slopes at the Hunt-Wesson Co. site in Davis, Calif. cost $1,500 per acre.

The original distribution system for Paris cost $348 per acre to install. The cost (in 1971) for the piping at the Davis site was about $1,250 per acre. Collection systems for the runoff are normally included under earthwork. At Davis the collection ditches amounted to 10 percent of the earthwork cost, or about $150 per acre.

At Paris, the annual operational cost is 5 cents per 1,000 gallons. The operational cost is reduced slightly by the income of 0.4 cent per 1,000 gallons from crops produced on the site. At Davis the annual cost is 5 to 10 cents per 1,000 gallons.

**Infiltration-Percolation**

Infiltration-percolation had been used with moderate loading rates (4 to 12 inches per week) as an alternative to discharging effluent to surface waters. High-rate systems (5 to 8 feet per week) have been designed to recharge ground water. Because high-rate systems have been carefully designed and monitored, they will be stressed in the following discussion.

Soil drainability on the order of from 4 to 12 inches per day or more is necessary for successful use of infiltration-percolation. Acceptable soil types include sand, sandy loams, loamy sands, and gravels. Very coarse sand and gravel are less desirable because they allow wastewater to pass too rapidly through the first few feet, where the major biological and chemical action takes place.

Other factors of importance include deep percolation rates; depth, movement, and quality of ground water; topography; and underlying geologic formations. To control the wastewater after it infiltrates the surface and percolates through the soil matrix, the subsoil and aquifier characteristics must be known. Recharge should not be attempted without specific knowledge of the movement of the water in the soil system.

Organic-loading rates of municipal systems range from 3 to 15 tons of BOD per acre per year. Industrial systems have operated successfully at 90 tons. Municipal systems generally pretreat the wastewater to secondary quality to maintain high liquid-loading rates. Industries have tended to rely more on the assimilative capacity of the soil, generally using pretreatment only to avoid operational problems.

Management practices important to infiltration-percolation systems include maintenance of hydraulic loading cycles, basin surface management, and system monitoring. Intermittent application of wastewater is required to maintain high infiltration rates, and the optimum cycle between inundation periods and resting periods must be determined for each individual case. Basin surfaces may be bare or covered with gravel or vegetation. Each type of surface requires some maintenance and inspection for a satisfactory operation. Monitoring, especially of ground water levels and quality, is essential to system management.

The filtering and straining action of the soil are excellent, so suspended solids, bacteria, and BOD are almost completely removed in most cases. Nitrogen removals are generally poor unless specific operating procedures are established to maximize denitrification. Phosphorus removals range from 70 to 90 percent, depending on the percentage of clay or organic matter in the soil matrix which will adsorb phosphate ions.

Wastewater treatment by infiltration-percolation varies considerably with soil characteristics and management practices. By careful management of the hydraulic loading cycle (2 to 3 weeks of wetting, 2 weeks of drying), Flushing Meadows, Ariz. has obtained nitrogen removals up to 80 percent. Overall nitrogen removal, taking into account the high nitrate concentration flushed to the ground water at the beginning of inundation, averaged 30 percent. Removals of phosphorus and heavy metals were also generally less than for irrigation.

The useful life of an infiltration-percolation system will be shorter, in most cases, than that of irrigation or overland flow. This is caused by unacceptably high loadings of inorganic constituents, such as phosphorus and heavy metals, and by the fact that these constituents are fixed in the soil matrix and not positively removed. Therefore, exhaustion of the fixation capacity for phosphorus and heavy metals will be a function of the loading rate and the fixation sites available. At Lake George, N. Y., phosphorus retention on the basis of recent monitoring in some percolation beds appears to have been exhausted. The system had been operating about 35 years at moderate rates of from 7 to 15 inches per week.

From the standpoint of environmental effects, infiltration-percolation is the least reliable of the three approaches relative to the best practicable criteria. However, most systems that have been monitored and managed properly proved to be quite reliable.

Capital and operating costs for infiltration-percolation systems will generally be less than those for irrigation or overland flow because less land is used and distribution is by gravity flow. For high-rate systems, however, pretreatment needs are substantially greater.

The capital costs for infiltration-percolation are for land, pretreatment, earthwork, transmission and distribution, and recovery. At Westby, Wis., basins were constructed in a 5 percent hillside. The land cost was $750 per acre; earthwork was $2,500 per acre. The earthwork cost at Flushing Meadows was $4,500 per acre. Others have calculated the cost of transmission and distribution at Flushing Meadows at $98,000. The recovery wells there cost $35 per foot, or $17,500 for each well.

Operation and maintenance costs for infiltration-percolation systems consist of costs for labor, maintenance, and power. At Flushing Meadows, the operating cost is 2.4 cents per 1,000 gallons, while at Whittier Narrows, Calif., it is 2.7 cents.

Simpson Lee Paper Co. operates two pulp and paper waste-disposal systems by infiltration-percolation. At Vicksburg, Mich., 1 inch per day is applied by spraying. The operating cost is 2.9 cents at Vicksburg. Pretreatment costs for primary settling are included.

### Other Land Application Techniques

There are several other approaches to land application, including subsurface leach fields, deep-well injection, and evaporation ponds. Such techniques are generally limited in their applicability. Leach fields are prevalent in rural areas for small systems involving septic tanks and are unlikely to become more widespread. Deep-well injection provides no substantial renovation to the wastewater and is not allowed by the best-practicable-treatment criteria unless pretreatment is of a sufficiently high quality. Evaporation ponds also have limited applicability because of their large land requirements and climatic constraints, but some are in use.

## B. Land Utilization Techniques

Wastes and sludges from wastewater treatment plants are often ultimately disposed of on the land by such processes as surface spreading or landfill disposal of dewatered and stabilized sludge, landfill disposal of incineration ash, and composting.

### Land Spreading of Sludge

Land spreading of either chemically- or biologically-stabilized sludge is generally similar to the land application of wastewater. Occasionally, land spreading is limited by the ability of the land to accept the large amounts of water in the sludge. More often it is limited by the ability of the land to accept high concentrations of salts, organic matter, heavy metals, and pathogenic organisms.

Sludge can be applied by spray or ridge and furrow irrigation. Procedures used in land application techniques are followed for site selection and cropping. Likewise, the amount of nitrogen compounds, nitrates and ammonia, is expected to be limiting. Ammonia may have to be reduced prior to application. Ammonia may interfere with seed germination, and nitrates may reach the ground water.

In Great Britain 20 to 30 communities practice land spreading. The solids content of the stabilized sludge varies between 2 and 5 percent. The application of less than 5 tons of dry solids per acre per year has been successful. Monitoring of heavy metals has not revealed problems at this level of application.

The Chicago Metropolitan Sanitary District is now spraying sludge on 7,000 acres. The land is prepared by leveling to less than 5 percent grade and building earth berms to control runoff. Application rates of 2 inches of sludge per year are expected to be successful. At higher rates, nitrogen compounds would have to be removed. Aeration techniques have been studied and should be successful in oxidizing ammonia nitrogen.

Another method of land spreading involves application of dried sludge, which contains less nutrient, namely nitrogen. When the dry sludge is packaged, as it is in Milwaukee, Wis., it can be sold as a soil conditioner. This conserves space in land disposal sites.

### Landfill of Sludge

Stabilized sludge, which has been adequately dewatered, can be disposed of by sanitary landfill, the controlled burial of waste beneath an earth cover. Sufficient land must be available, runoff and percolation of the leachate to the groundwater must be controlled and monitored, and odors and pathogenic problems must be dealt with. The U.S. Department of Agriculture is experimenting with a variety of sludges, successfully burying the sludges in 2-foot-wide, 2-to 4-foot deep trenches with a 1-foot soil cover. Other methods such as deep disking and rotary tilling will also be tested.

Another method of disposal is sanitary landfilling liquid sludge mixed with solid waste. In addition to the safegaurds cited above, careful consideration must also be given to the site characteristics and the nature and quantity of the waste when designing for this method of disposal.

### Landfill of Incinerator Ash

Where land is scarce or distant, incineration is often an economically attractive method for disposing of treatment-plant sludge. The ash from incinerated municipal sludges is only from 3 to 10 percent of the mass of dewatered sludge cake, and incineration reduces odors and pathogens. The stack discharges to the atmosphere and the air environmental concerns must be properly addressed.

### Composting and Final Disposal

Sewage sludge can be decomposed by composting, an aerobic digestion process that converts organic material into a soil conditioner. Moisture content of the sludge is reduced to approximately 50 percent. Biological action heats the sludge to an average temperature over 70° C for an excess of 5 days. Nearly all pathogenic organisms are destroyed. The end product can be applied to the land or put into a sanitary landfill.

## C. Nonpoint Sources of Pollutants

Information on nonpoint sources of pollutants, such as runoff from agriculture, construction, and mining activities is being published pursuant to Section 304(e) of the Act. However, the information and techniques discussed in that publication should be an integral part of the total area-wide waste management system. All techniques of water pollution abatement should be considered in area-wide programs to arrive at the best practicable treatment.

# CHAPTER IV: WASTE MANAGEMENT TECHNIQUES INVOLVING TREATMENT AND DISCHARGE

There are an estimated 21,118 publicly-owned treatment works (POTW's) in the United States employing different methods of treatment (Table 4). Treatment and discharge is the technique used by the largest number of such facilities.

The development of treatment and discharge technology follows a basic pattern (Figure 3): Raw discharge, primary treatment, secondary treatment, advanced waste or tertiary treatment for nutrient removal, and renovation. The initial goal of the Act requires that POTW's utilizing treatment and discharge meet secondary treatment as defined by EPA by July 1, 1977 or June 1, 1978 (for new construction). The second goal of the Act is to provide application of best practicable treatment by July 1, 1983.

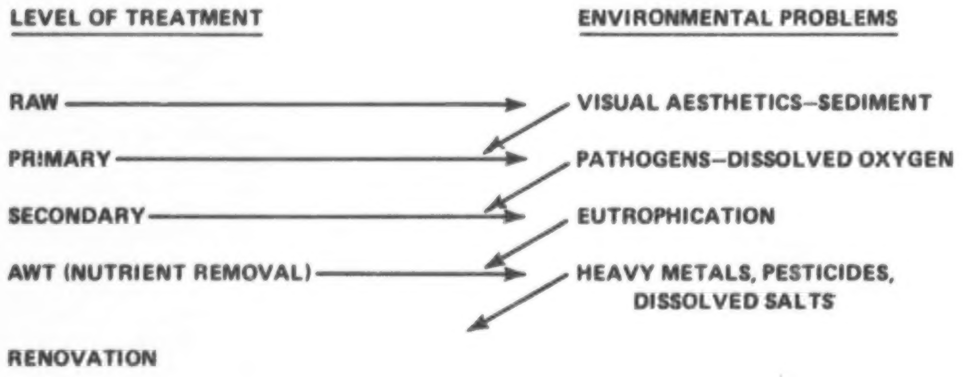

LEVEL OF TREATMENT
ENVIRONMENTAL PROBLEMS
RAW
VISUAL AESTHETICS–SEDIMENT
PRIMARY
PATHOGENS–DISSOLVED OXYGEN
SECONDARY
EUTROPHICATION
AWT (NUTRIENT REMOVAL)
HEAVY METALS, PESTICIDES, DISSOLVED SALTS
RENOVATION

Figure 3. ENVIRONMENTAL PROBLEMS ASSOCIATED WITH TREATMENT AND DISCHARGE

## Table 4. ESTIMATED DISTRIBUTION OF PUBLICLY-OWNED TREATMENT WORKS

| | Major Plants (1 MGD or more) | | | Minor Plants (1 MGD or less) | | Total |
|---|---|---|---|---|---|---|
| | WQL[a] | EL[b] | EL-OO[c] | WQL | EL | |
| None | 29 | 32 | 3 | 944 | 1,462 | 2,467 |
| Primary | 549 | 366 | 62 | 828 | 1,278 | 3,022 |
| Pond | 87 | 50 | 7 | 1,800 | 2,791 | 4,728 |
| Trickling Filter | 574 | 382 | 57 | 1,367 | 2,015 | 4,338 |
| Activated Sludge | 235 | 219 | 35 | 872 | 1,162 | 2,488 |
| Extended Aeration | 42 | 29 | 4 | 686 | 1,071 | 1,828 |
| Secondary-Other | 112 | 77 | 13 | 518 | 879 | 1,586 |
| Land Disposal | 5 | 3 | – | 58 | 91 | 157 |
| Tertiary | 42 | 30 | 4 | 169 | 263 | 504 |
| Total | 1,676 | 1,188 | 185 | 7,242 | 11,012 | 21,118 |

[a] Plants located on water-quality-limited segments.

[b] Plants located on effluent-limited segments.

[c] Plants located on effluent-limited segments with ocean outfalls.

Criteria for best practicable treatment must be environmentally sound as well as technologically achievable. The areas of concern which are likely to warrant additional attention after the application of secondary treatment controls in 1977 include oxygen-demanding material, nutrients which contribute to eutrophication (phosphorus and nitrogen), heavy metals, pesticides, and dissolved solids.

Review of the literature and existing water quality surveys indicates that protection of the dissolved oxygen in receiving waters has the highest priority in the vast majority of cases. Approximately 50 percent of the Nation's POTW's discharge into receiving waters where the water quality problem is unsolved by existing regulations. In these water-quality-limited segments, almost all of the plants are expected to require an effluent containing less oxygen-demanding material than that achievable by secondary treatment.

Eutrophication typically occurs mainly in lakes and slow-moving estuaries. A recent study reveals that only 15 percent of the POTW's discharge to lakes, and half of these (or 7.5 percent of the total) require phosphorus control and one-third (or 5 percent) require nitrogen control. River and estuary needs for nutrient control have not presently been surveyed on a national scale.

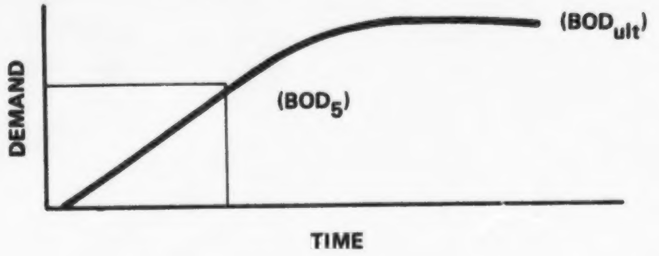
The fecal coliform standards as established by the secondary treatment criteria were set at levels which would ensure the highest recreational (primary contact recreation) use.

The parameter used in secondary treatment to measure oxygen-demanding material in waste is 5-day biochemical oxygen demand ($BOD_5$). The $BOD_5$ test essentially measures the oxygen demand of only the carbonaceous organic material in the wastewater effluent. It usually does not measure the oxygen demand of the nitrogenous organic material, which exerts its effect in the test later than the carbonaceous material (Figure 4).

A parameter, ultimate oxygen demand (UOD), is a superior parameter for measuring the oxygen demand from municipal plants and is thus superior in protecting the oxygen level of the stream since it includes both sources of biological oxygen demand (the carbonaceous and nitrogenous) and allows credit for any dissolved oxygen in the effluent. A similar parameter, ultimate biological oxygen demand (UBOD), can be used where no nitrogenous demand is expected. A third useful parameter to evaluate oxygen demand is chemical oxygen demand (COD). This test measures carbonaceous demand for oxygen from both biodegradable and nonbiodegradable compounds and is intended to prevent the discharge of slowly-degrading industrial waste. Consideration should be given to COD in effluents from POTW's which receive substantially nonbiodegradable industrial wastes.

## SOURCES

### CARBONACEOUS DEMAND



$$BOD_{ult} = 1.5\ (BOD_5)$$

### NITROGENOUS DEMAND

$$NH_3 + 2O_2 = H^+ + NO_3^- + H_2O$$

$$NH_3 - N = 14;\ O_2 = 64$$

$$NOD_{ult} = \frac{64}{14}\ (NH_3\,N) = 4.6\ (NH_3 - N)$$

## CREDIT

DISSOLVED OXYGEN = 1.0 (DO)

NOTE:

$K_1$ IS GENERALLY 1.5

$K_2$ IS GENERALLY 4.6

## FORMULAS

$$UOD = K_1\ (BOD_5) + K_2\ (NH_3N) - 1.0\ (DO)$$

$$UBOD = K_1\ (BOD_5) - 1.0\ (DO)$$

Figure 4. DERIVATION OF ULTIMATE OXYGEN DEMAND (UOD)

Carbonaceous oxygen demand is the largest source of biological-oxygen demanding-material in effluents from raw discharge or primary treatment (Table 5). In secondary treatment (high-rate system) as defined by EPA, the nitrogenous demand is by far the largest residual demand in the effluent. Thus, UOD as a means of measurement is particularly useful.

In addition to the treatment of wastewaters which pass through municipal plants, other approaches to improve water quality have been examined, including treating combined sewer overflows, treating storm water, and controlling nonpoint sources. Demonstrated technology to control storm water and nonpoint sources essentially does not exist. Efforts are being made to

## Table 5. TYPICAL VALUES OF ULTIMATE OXYGEN DEMAND (UOD)

| | Carbonaceous | Nitrogenous | Total (UOD) | % Removal |
|---|---|---|---|---|
| Raw | 300 | 100 | 400 | 0 |
| Primary | 180 | 95 | 275 | 31 |
| Secondary (High-Rate) | 45 | 90 | 135 | 69 |
| Secondary (Conventional) | | | | |
| (Winter) | 23 | 90 | 113 | 74 |
| (Summer) | 23 | 23 | 46 | 88 |
| Two-Stage Nitrification | 23 | 23 | 46 | 88 |
| Advanced Waste Treatment | 8 | 12 | 20 | 95 |

## Table 6. YEARLY CAPITAL COST OF INCREASED TREATMENT AND COMBINED SEWER OVERFLOW CONTROL IN SELECTED CITIES

| | Estimated Increased Treatment Cost[a] ($/pound UOD Removed/yr) | Overflow Controls Cost ($/pound UOD Removed/yr) |
|---|---|---|
| Cleveland, Ohio | 0.21 | 2.22 (Filtration) |
| Oakland, Calif. | 0.39 | 13.70 (Holding tanks)<br>13.60 (Sewer repair)<br>8.80 (Fine screening)<br>8.80 (System control) |
| Atlanta, Ga. | 0.19 | 28.00 (Separate systems)<br>0.51 (Storage and screening)<br>1.84 (Storage and chlorination) |
| Bucyrus, Ohio | 0.48 | 42.10 (Separate systems)<br>8.35 (Lagoons)<br>27.00 (Primary treatment) |
| New York City, N.Y. | 0.98 | 21.20 (Overflow control) |
| Kenosha, Wis. | 0.22 | 11.80 (Storage and treatment)<br>23.80 (Storage and treatment) |
| Sacramento, Calif. | 0.37 | 22.60 (Storage and treatment) |
| Chippewa Falls, Wis. | 0.46 | 19.80 (Storage and treatment) |

[a] Additional capital cost over secondary treatment to achieve seasonal nitrification.

quantify the problems and identify the effects on receiving waters.

The combined sewer overflow problem is better quantified, and EPA research has demonstrated many types of treatment and control systems. On an amount basis, the cost of removing oxygen-demanding material by combined sewer overflow treatment is much greater than the cost resulting from removal by increasing treatment at the plant (Table 6). This is always true on a

## Table 7. CAPITAL COST OF INCREASED TREATMENT AND COMBINED SEWER OVERFLOW CONTROL ON A YEARLY AND PER-STORM-ONLY BASIS[a]

| COST ON A YEARLY BASIS | | |
|---|---|---|
| | Estimated Increased Treatment Cost[b] | Overflow Control Cost |
| Capital Cost | $150,000 | $895,000 |
| UOD removed (pounds/year) | 324,000 | 45,000 |
| Cost ($/pound of UOD removed/year) | 0.46 | 19.80 |
| **COST ON A PER-STORM-ONLY BASIS** | | |
| Capital Cost | $150,000 | $895,000 |
| UOD removed during storm only (pounds/storm) | 111 | 4,905 |
| Cost ($/pound of UOD removed/storm) | 1,350 | 182 |

[a] Chippewa Falls, Wis., 5 ea. storm.

[b] Additional capital cost over secondary treatment to achieve seasonal nitrification.

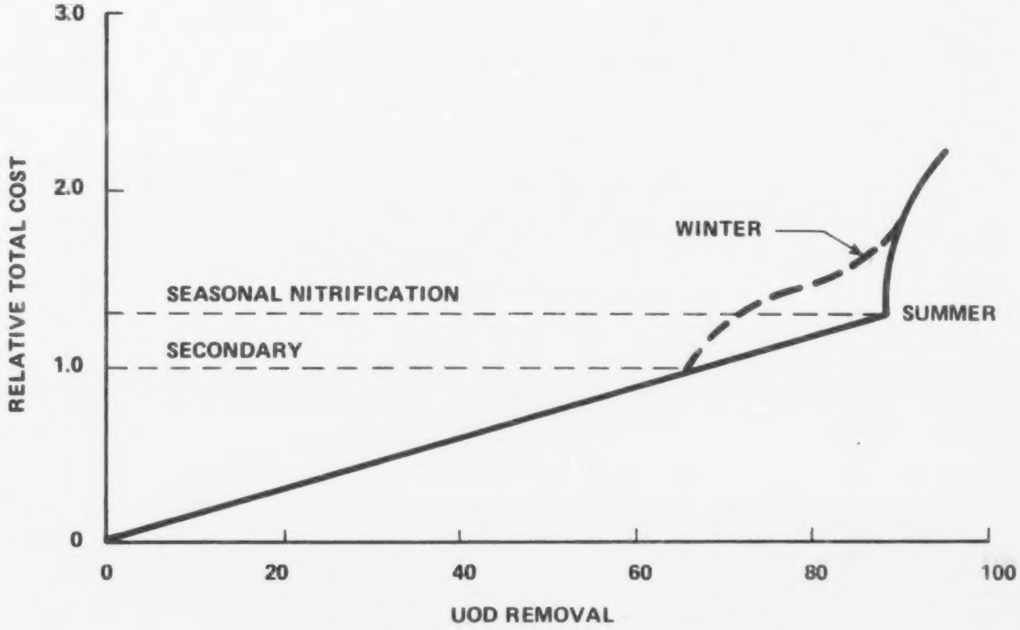


Figure 5. COST VS. PERCENT OF UOD REMOVED

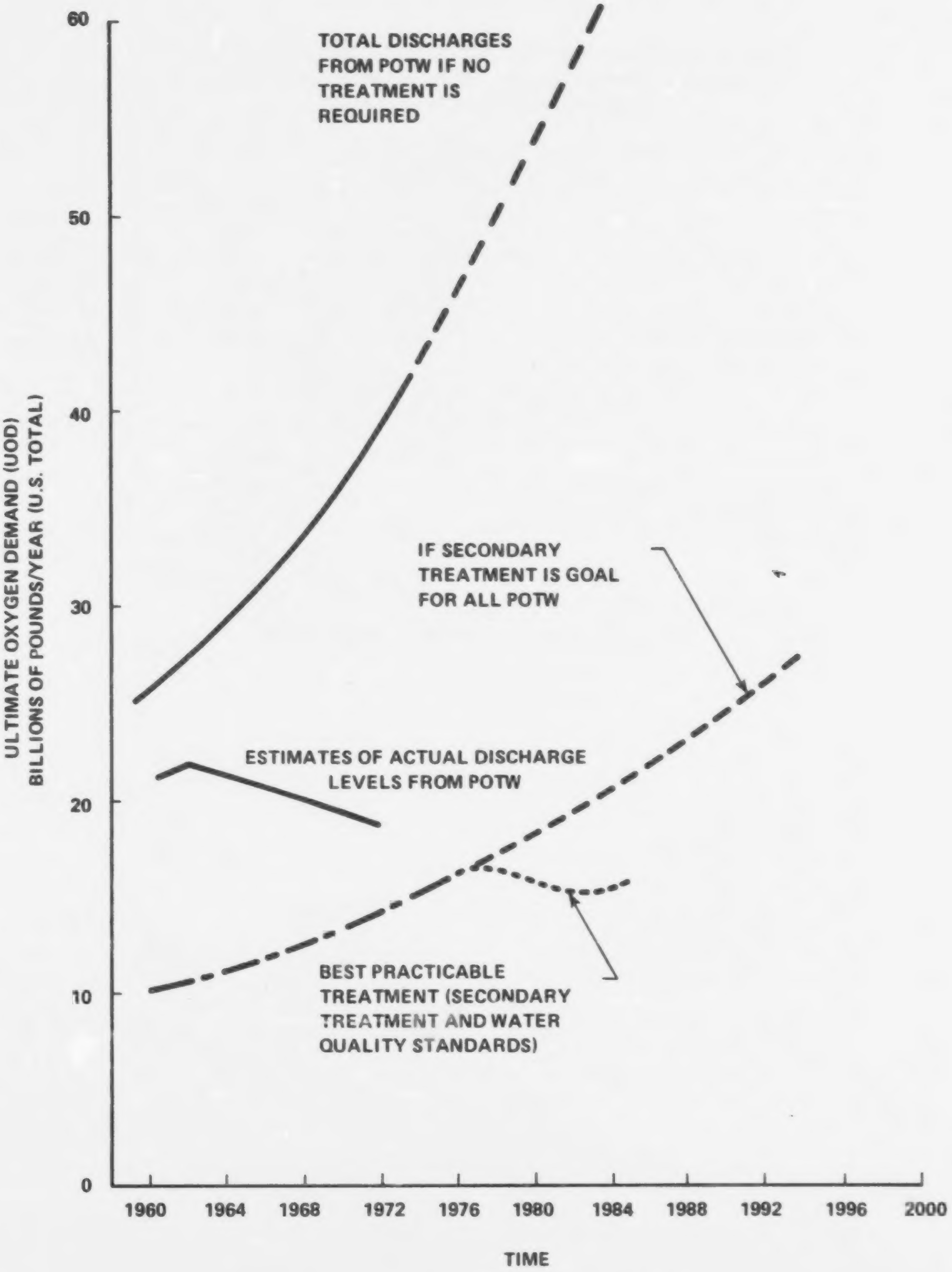


Figure 6. UOD REMOVAL, 1960-2000

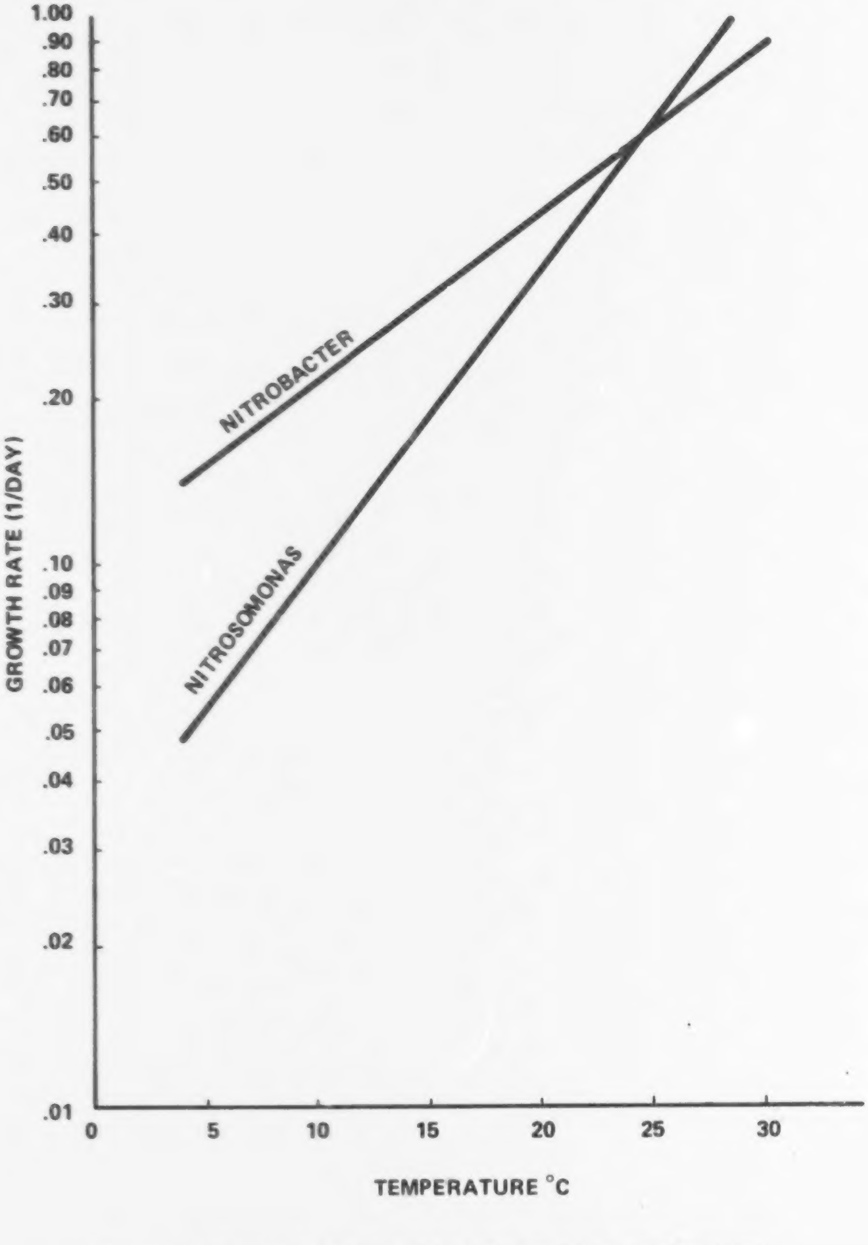


Figure 7. EFFECT OF TEMPERATURE ON THE GROWTH RATE OF NITRIFIERS

## Table 8. ENERGY REQUIREMENTS OF ACTIVATED SLUDGE TREATMENT

| | Secondary | Seasonal Nitrification | % Increase |
|---|---|---|---|
| **Electrical** | | | |
| Amount used | 5 watts/cap | 7.5 watts/cap | + 50% |
| Percent of total electrical usage for a city | 0.4% | 0.6% | |
| Annual cost | 44 cents/cap/yr | 66 cents/cap/yr | |
| **Fossil fuel to incinerate sludge** | | | |
| Amount used | 370 Btu/cap/day | 280 Btu/cap/day | -25% |
| Comparative usage | 1 gal of fuel oil/cap/yr | 3/4 gal of fuel oil/cap/yr | |
| Annual cost | 12 cents/cap/yr | 9 cents/cap/yr | |

yearly basis, but it is not always true on an event basis (Table 7). Also, the water quality benefits from overflow treatment are poorly documented. Overflow treatment and control needs vary greatly from one city to the next and can best be handled on a case-by-case basis. Systems with combined sewer overflows must be controlled to minimize the discharge of pollutants during wet-weather conditions.

A study conducted by EPA to determine the level of effluent quality required to ensure that 90 percent of the rivers and streams would meet dissolved oxygen (DO) criteria for fish and wildlife standards in fresh water—5 milligrams per liter (mg/l) of DO—revealed that a yearly average of UOD of 33 mg/l was required. Statistically, this results in an approximate monthly maximum of 50 mg/l and a weekly maximum of 75 mg/l.

The cost for removing oxygen-demanding material from wastewater is economically reasonable up to 88 percent removal (Figure 5). Removals greater than this level result in much higher marginal costs per pound of pollutant removed.

The secondary treatment requirements in combination with water quality standards would offset the increased rate of UOD discharge associated with increased population (Figure 6).

The rate of biological oxygen removal resulting from the nitrifying action of ammonia varies dramatically with temperature (Figure 7). With very cold waters (either receiving waters or in wastewater being treated biologically), the nitrification process is slowed, reducing the importance of removing ammonia. However, in lakes and reservoirs where the water temperature increases, ammonia becomes more important and may still require year-round control.

As the environmental significance of ammonia diminishes with lower temperatures, the economic cost of satisfying its oxygen demand rises. The technology to achieve nitrification is well understood. As early as the late 1920's, plants were designed to accomplish 88 percent UOD removals. The capital and operating costs of seasonal nitrification in biological processes, however, will increase with decreasing wastewater temperature, as a result of decreasing biological nitrification rates. Likewise, in a physical-chemical treatment process such as ammonia stripping, an increase in cost will occur with decreasing temperature. If the nitrification is applied only to wastewaters above 20° C, the cost increase (both capital and operating) will be typically 30 percent greater than the cost of achieving secondary treatment. The cost of year round nitrification would be 75 percent greater than required secondary treatment.

In an EPA study where the discharge was to streams with intermittent or no flow, the nitrified effluents were sufficient to meet fish and wildlife standards in an estimated 90 percent of the cases. However, in only a few cases would secondary treatment levels meet these standards because of excessively low dissolved oxygen and fish toxicity caused by uncontrolled discharge of ammonia.

Nitrification would result in approximately a 50 percent increase in electrical power consumption for municipal waste treatment (Table 8). The resulting total demand for wastewater treatment would be less than 1 percent of the total community demand.

As a tradeoff for electrical demand, nitrification would produce less sludge and reduce fossil fuel requirements for incineration by up to approximately 25 percent (Table 8). Solid-waste management problems are likewise decreased. With a decrease of 25 percent in total sludge production, air pollution problems arising from incineration would be reduced as a result.

### A. Flow Reduction

Information on reducing the total flow of sewage is being prepared for a report to Congress pursuant to Section 104(o)(2) of the Act. The techniques discussed in that report should be recognized as part of the total areawide waste management system and essential to achieving the best practicable treatment.

Excluding reuse and recycling, the techniques for reducing total flow of sewage can be placed into four major categories. The first is the reduction of infiltration and inflow into the sewage collection system. Infiltration problems must be solved, according to Section 201(g)(3) of the Act, before a Federal grant can be made. The procedures for complying with this section are contained in the regulations "Grants for Construction of Treatment Works" (40 CFR Part 35.927). The second, the reduction of household water consumption, involves installing devices to reduce water usage in existing household appliances and fixtures as well as designing and installing new appliances and fixtures that use less water. The third category involves economics and pricing policies to reduce use of water. A final technique is to change public attitudes as they relate to water consumption.

### B. Techniques to Achieve Secondary Treatment and Nitrification

Extensive information has been available since the 1920's on the biological techniques to achieve the effluent quality required by secondary treatment and nitrification. The techniques fall into four categories: (1) biological treatment, including ponds, activated sludge, and trickling filters; (2) physical-chemical processes, including chemical flocculation, filtration, activated carbon, breakpoint chlorination, ion exchange, and ammonia stripping; (3) land application systems; and (4) systems which combine the previous techniques.

#### Biological

The most widely used systems of wastewater treatment employ biological treatment. With the exception of anaerobic ponds, the systems use aerobic (air- or oxygen-requiring) metabolism to degrade the pollutants. Oxygen and bacterial cultures can be provided in many ways, including large shallow ponds exposed to the air, trickling filters with a bacterial culture supported on a rock or synthetic medium which is exposed to the atmosphere, and activated sludge, in which the culture of bacteria is aerated with air or oxygen.

**Ponds.** Sewage oxidation ponds, often called lagoons, are widely used throughout the United States. These systems require little energy because they rely on natural forces such as aeration and produce minimum quantities of sludge. Since the design and operation of ponds vary widely, it is hard to generalize on their capabilities. A multicelled pond with intermittent-discharge capabilities can achieve secondary treatment and best practicable treatment without additional aeration or filtration if average loading does not exceed 20 pounds of $BOD_5$ per acre per day and if it has at least a 6-month storage capability. However, this is not true of ponds which discharge continuously. Normally, ammonia is readily converted; however, BOD removal and ultimate removal of nitrogen, both of which are dependent upon the effective capture of suspended solids, are more difficult.

Ponds with lesser capabilities can employ mechanical aeration or rely on pretreatment (such as primary sedimentation) or postfiltration to achieve the required levels. High solids carryover, seasonal changes, algae growth, hydraulic short-circuiting, and overload conditions are problems which arise in many ponds and make achieving the standards more difficult.

In the 0.1- to 4.0-MGD size range, total costs for ponds range from $3 to $9 per person per year, versus from $9 to $20 for activated sludge or trickling filters. Where land costs are high, however, ponds lose their cost advantages.

**Activated sludge.** The activated sludge process consists of an aerator and clarifier and is usually preceded by primary sedimentation.

The aerator, utilizing air (either diffused or mechanical) or pure oxygen, provides conditions for a suspended microbial growth which metabolizes the biodegradable wastes. The microbial growth is clarified and a portion recycled to maintain metabolism in the aerated tankage. The other portion (the build-up of microbial growth) and the primary solids go to an appropriate solids-handling facility. The use of chemicals—lime, ferric and ferrous salts, alum, sodium aluminate, or polymers—can enhance the capture of particulates in both primary sedimentation and secondary clarification, thus improving operation of the process. These techniques are examples of combined biological and physical-chemical treatment.

Activated sludge plants can be operated to establish and maintain bacteria to nitrify ammonia. This can be accomplished by supplying additional aeration, by ensuring that the nitrifying organisms propagate at a faster rate than they are destroyed, and by providing sufficient capacity in the aerator and/or clarifier to handle the higher mass of microbial growth resulting from the reduced wasting rate.

Several other new techniques have been employed to increase the capabilities of activated sludge plants without increasing the size of aerators or clarifiers. Rotating disks have been tested successfully in pilot plants. By using a disk, extra biological solids can be maintained in the aerator. A pilot plant in Tracy, Calif., used a synthetic red wood media to allow a larger culture of bacteria to be maintained in the aerator. A similar facility is operational in San Pablo, Calif.

Separate biological nitrification, which is basically similar to an activated sludge system, can also be used. The biodegradable wastes are largely reduced to approximately secondary quality in preliminary treatment. The aerobic microbial growth is then largely established and maintained on the metabolism of ammonia. A separate nitrification stage is more reliable and can remove ammonia at much colder temperatures than the methods previously discussed. The capital and operational costs are expected to be from 25 to 75 percent greater than those for single-stage systems.

Another new system, tested in pilot plants at Washington, D. C. and Central Contra Costa, Calif., uses chemical treatment to reduce the organic loading to the activated sludge aerator. The pilot results were excellent, with ammonia removed easily and reliably by nitrification. The system, however, does produce high quantities of sludge.

Still another system using combined biological and physical-chemical methods is to employ breakpoint chlorination or ion exchange (both discussed later) to remove the ammonia from a nonnitrifying biological plant to acceptable levels.

**Trickling filters.** Trickling filter plants are similar to activated sludge plants except that microbial growth is not suspended. Instead it is attached to a fixed medium, such as rocks or a synthetic material, over which the wastewater is repeatedly recycled. The excessive microbial growth is sloughed off the media and captured in a clarifier. Trickling filters employing standard loadings below 10 to 20 pounds of $BOD_5$ per 1,000 cubic feet of rock medium per day can meet secondary treatment requirements. Synthetic media are available with larger void spaces and greater surface area per cubic foot. These media have been successfully piloted and operated at loading rates of as much as 2 to 5 times that of rock media; they can be operated at higher hydraulic loading rates. The performance and costs are generally competitive with equivalent activated sludge systems.

A modification of the trickling filter concept involves rotating closely packed disks through the sewage. Large masses of bacteria are maintained and aerated on the disk during rotation. Initial work in Passaic Valley, N. J., Pewaukee, Wis., and at the University of Michigan has demonstrated the system's capabilities. The rotating disk can be used in the same variety of applications as rock or synthetic media filters, namely as conventional secondary treatment for bulk removal prior to subsequent treatment (roughing filter) or to achieve nitrification.

### Physical-Chemical

Chemical flocculation of suspended and colloidal solids (using lime, ferric or ferrous salts, alum, and sodium aluminate, often with polymer addition and subsequent sedimentation) can often achieve suspended solids effluent quality equivalent to secondary treatment. The dissolved BOD and COD are not substantially removed, and wastewater with high dissolved-organic concentrations may not achieve effluent quality equivalent to secondary treatment without additional treatment.

Suspended solids and the associated BOD can be removed by filtration in any of the methods discussed to improve the effluent quality above secondary treatment. A wide selection of filtration media is available. Either pressure or gravity filtration can be used. Removal of suspended solids is usually desirable prior to activated carbon, breakpoint chlorination, ion exchange, or ammonia stripping.

Activated carbon has proven its ability to adsorb organic material in wastewater. Because activated carbon does not rely on bacterial action, it can remove biodegradable and nonbiodegradable material. Several techniques have been used to bring the activated carbon in contact with the wastewater; various forms of carbon have been used. Granular carbon is the most widely used and highly developed technique. Contact methods include pressurized downflow, gravity downflow, and suspended-bed upflow. Powdered carbon systems can also be used and show excellent potential, although still in a research and development stage.

Breakpoint chlorination (superchlorination) can be used to reduce ammonia concentrations in wastewater. Chlorine, sodium hypochlorite, and calcium hypochlorite can be added at ratios between 7.6:1 and 10:1 of chlorine to ammonia nitrogen. This will oxidize the ammonia to nitrogen gas if reaction takes place at about pH 7. Proper controls and operation must be maintained at all times.

Selective ion exchange systems are available for removal of ammonia. The ion exchange medium normally used is clinotilolite. After regeneration with a salt and/or lime brine, it will exchange either the sodium ion or calcium ion for

## Table 9. ESTIMATED COSTS FOR COMPLETE SEPARATION OF STORMWATER AND SANITARY SEWERS

| City | Total Project Cost | Cost/acre | Cost/ capita |
|---|---|---|---|
| Chicago, Ill. | $2,300,000,000 | $17,000 | $482 |
| Cleveland, Ohio | 470,000,000-<br>700,000,000 | 12,000-<br>18,000 | 360-535 |
| Concord, N.H. | 8,000,000 | ........ | 280 |
| Detroit, Mich. | 1,315,000,000 | ........ | 360 |
| Haverhill, Mass. | 30,000,000 | 10,500 | 650 |
| Kansas City, Kans. | 20,000,000 | 7,745[a] | 187 |
| Lawrence, Kans. | 30,000,000 | 13,500 | 915 |
| Lowell, Mass. | 70,000,000 | 12,000 | 780 |
| Milwaukee, Wis. | 425,000,000 | 8,250 | 440 |
| New Haven, Conn. | 10,000,000 | 16,363[a] | 560 |
| New York, N.Y. | 4,000,000,000 | 25,000-<br>30,000 | 492 |
| Portland, Ore. | 100,000,000<br>250,000,000 | 3,100-<br>7,750 | 260-652 |
| Seattle, Wash. | 145,000,000 | 3,890 | 260 |
| Spokane, Wash. | 50,000,000 | 1,800 | 415 |
| Toronto, Ontario | 285,000,000 | 17,000 | ........ |
| Washington, D.C. | 214,000,000 | 18,000 | 250 |
| Total | $9,662,000,000[b] | $12,427[b] | $468[b] |

[a] Based on actual project cost.

[b] Using the average costs for those cities reporting ranges.

the ammonium ion in wastewater. The regeneration brine contains the removed ammonia. The removal from and the disposal of ammonia can be accomplished by steam distillation and subsequent condensation and recovery of ammonium hydroxide. Electrolytic or chlorine oxidation of the ammonia in the brine to nitrogen gas has been demonstrated in pilot studies. Hot air stripping of ammonia from the brine, followed by acid readsorption and precipitation of ammonia salts, has also been investigated. The salts can be used as fertilizer.

Ammonia can be stripped from wastewater, although it requires from 100 to 800 cubic feet of air per gallon of water. The ammonia is usually discharged directly to the atmosphere, but this practice should be avoided in areas where the discharge could degrade the quality of the atmosphere. The process has other disadvantages: Lime or other caustic chemicals must be added to the influent before the ammonia can be stripped. Further, effectiveness of stripping decreases with decreasing atmospheric temperature.

### Land Application

Often land treatment is not viewed as a treatment and discharge process. However, an underdrain or similar water removal procedure used with overland flow can achieve the effluent quality required by secondary treatment standards. This technique is presently being demonstrated in Muskegon County, Mich.

## C. Storm and Combined-Sewer Control

Storm and combined-sewer overflows can be a source of significant quantities of pollutants. Demonstrated technology to control storm sewer discharges does not exist. Efforts are being made to quantify the problem and identify the effect on receiving waters.

The combined-sewer overflow problem is better quantified, and EPA research has demonstrated many types of control and treatment techniques. The techniques fall into five categories: (1) separation of sewage and storm collection systems; (2) operational control of the existing system; (3) storage and subsequent treatment; (4) dual use; and (5) direct treatment of overflows. Combinations of the techniques often result in the most cost-effective solutions, as has been demonstrated in Atlanta, Ga. and Bucyrus, Ohio.

### Separation of Combined Sewers

One approach to minimizing overflows from combined sewers is to separate the systems. Complete separation is the most costly. In 1964, the cost for separating sewers in 16 cities was estimated at $9.6 billion (Table 9), for an average cost of $468 per person. The 1964 estimate for the United States was $25 to $30 billion. Today, the cost may be in excess of $50 billion.

Another approach is to partially separate the systems in a cost-effective manner. Partial separation includes separation of roof drains, area drains, foundation drains, air conditioning drains, and yard drains. This procedure would have cost $176 per person in 1964 (Table 10), or a total U. S. cost of $10.4 billion. The cost now may be in excess of $20 billion.

### Control of Combined Sewers

Proper design, maintenance, and control of combined sewers (as now required for best practicable treatment) can markedly reduce the discharge of pollutants. A manual of practice prepared by the American Public Works Association for the Federal water pollution control program points to design and maintenance practices as the key to minimizing overflow pollution. Also, a study of the Hudson River concluded that proper maintenance of valves and other flow-regulating devices could substantially reduce overflows.

An even more effective control technique is regulating combined collection systems so as to utilize their capacity to the utmost. For example, Metro-Seattle uses continuous flow measurements and computerized control to divert flow to portions of the system that are under-utilized. A similar system operated by the Minneapolis-St. Paul Sanitary District (now the Metropolitan Sewer Board) reduced the quantities of overflow by 66 percent and the duration by 88 percent. The control system cost $1.75 million and had approximately the effect of a separation project costing $200 million.

Another control system which has experimentally shown promise of reducing pollution is periodic flushing of sewers during dry weather. Estimated to cost between $620 and $1,275 per acre in 1972, flushing can substantially reduce the wash out and overflow of the deposited materials from the system.

### Storage and Treatment of Combined Overflows

An excellent way to eliminate or reduce combined overflows is to store and subsequently treat the overflows. This technique was successfully demonstrated in Chippewa Falls, Wis. An asphalt-paved detention basin was built to retain overflows up to a 5-year storm. The system captured 93.7 percent of the quantity of overflow, which was treated in the wastewater treatment plant during low-flow periods. The capital cost in 1972 was $6,780 per sewered acre.

Other storage devices have been tested. In Cambridge, Md., a 200,000-gallon flexible underwater container stores combined sewer over-

### Table 10. ESTIMATED COSTS FOR PARTIAL SEPARATION OF STORMWATER AND SANITARY SEWERS

| City | Total Project Cost | Cost/ acre | Cost/ capita |
|---|---|---|---|
| Des Moines, Iowa | $25,000,000 | $7,800 | $170 |
| Elmhurst, Ill. | 8,770,000 | ...... | 237 |
| Eugene, Ore. | 3,410,000 | 3,100 | 76 |
| Findlay, Ohio | 15,108,000 | ...... | 500 |
| Granite City, Ill. | 13,200,000 | 4,900 | 330 |
| Hannibal, Mo. | 613,000 | ...... | 43 |
| Kendallville, Ind. | 969,000 | ...... | 143 |
| Lafayette, Ind. | 5,024,000 | ...... | 120 |
| La Porte, Ind. | 9,187,000 | ...... | 437 |
| Lathrup Village, Mich. | 961,500 | ...... | 302 |
| Louisville, Ky. | 30,538,000 | ...... | 73 |
| Michigan City, Ind. | 3,500,000 | ...... | 95 |
| Minneapolis, Minn. | 30,000,000 | 3,040 | 69 |
| Mishawaka, Ind. | 4,392,000 | 972 | 129 |
| Napa, Colo. | 1,549,000 | 640 | 52 |
| Sedalia, Mo. | 4,470,000 | ...... | 213 |
| Seattle, Wash. | 69,000,000 | 1,860 | 124 |
| Tacoma, Wash. | 7,960,000 | ...... | 53 |
| Total | $223,651,500 | $3,187[a] | $176[a] |

[a] Average.

flows. This device contained 96 percent of the overflow for subsequent treatment. The capital cost was $1.85 per 1,000 gallons captured.

**Dual Use**

Several methods have been used to directly treat the overflow from combined sewers. In Kenosha, Wis., the existing wastewater treatment plant is operated to maximize biological adsorption in the aerator during wet-weather flows. The adsorbed organics are later biologically degraded. Prior to construction of the dual-use facility, removals of suspended solids and $BOD_5$ were 64 and 82 percent, respectively. Following construction, removals were 88 and 94 percent. During wet weather, the plant still removes 91 percent of suspended solids and 82.5 percent of $BOD_5$. This technique cost $917 per sewered acre and was $7 million cheaper than separation. Another technique is to expand the wastewater plant so that it can treat overflows, either partially or fully. The District of Columbia has designed primary sedimentation tanks to handle excessive wet-weather flows. The excessive flows will receive primary treatment and chlorination.

**Treatment of Combined Overflows**

Other techniques have shown capability of treating excessive wet-weather flows where land is scarce. One such technique is high-rate dual-media filtration. Experimental results showed 93 percent removal of suspended solids and 65 percent removal of BOD$_5$ at high filter rates. In 1971, estimated capital cost for this system was approximately $23,000 per MGD of design capacity. The expected operational cost was from $90,000 per year for a 25-MGD plant to $390,000 for a 200-MGD plant. Another technique uses a rotating fine screen. In pilot plant tests, 34 percent of suspended solids, 27 percent of COD, and 99 percent of floatable and settleable solids were removed. The estimated cost for a 25-MGD plant is 22 cents per 1,000 gallons treated. In-sewer fixed screens with screen openings ranging from one-eighth inch to 1 inch have been tested, with varying degrees of success. Chemical treatment using polyelectrolytes, lime, alum, or ferric chloride is also being investigated to help treat excessive wet-weather flows.

Another treatment technique is disinfection. Chlorine gas can be used just as it is in wastewater treatment plants. Recently, however, electrochemical cells have been used to produce hypochlorite disinfectant in isolated or unattended installations. The cell uses 1.6 kilowatt hours of electricity and 2.1 pounds of salt per pound of sodium hypochlorite produced. Large installations are expected to produce chlorine for 3 to 4 cents per pound.

### D. Advanced Waste Treatment (Nutrient Removal)

The term "advanced waste treatment" is used in many different ways. In this report the term is used to describe unit processes or systems designed to prevent the discharge of pollutants or nutrients which can cause accelerated euthrophication of the receiving waters. The key nutrients are carbon, nitrogen, and phosphorus. Euthrophication may be a significant problem in certain receiving waters. Nutrient removal, however, is not required by best practicable treatment on a national basis. Advanced waste treatment (or nutrient removal) techniques are usually used in conjunction with the techniques to achieve secondary treatment. The techniques fall into four categories: (1) biological; (2) physical-chemical; (3) land application; and (4) combinations.

#### Biological

Biological methods to remove carbon are the same techniques discussed earlier—ponds, activated sludge, and trickling filters. When higher degrees of removal are necessary, however, longer detention periods are required or improved liquid solids techniques such as larger clarifiers or filtration must be employed.

The biological method to remove nitrogen is nitrification followed by denitrification. Both can be accomplished in a mixed suspended culture followed by clarification (similar to activated sludge) or on a fixed medium (similar to a trickling filter). The Blue Plains Plant at Washington, D. C. is currently building a 300-MGD biological nitrification and denitrification system. Separate denitrification requires an organic supplement. Methanol has been most commonly used. For successful operation, approximately 3.5 parts of methanol are required to each part of nitrate nitrogen. Both nitrification and denitrification are temperature-sensitive. At 10° C. the metabolic kinetic rates can decrease to less than 20 percent of the rates observed at 30° C. Normally, nitrogen cannot be removed by a single-stage biological process. However, in recent experiments at a pilot plant in Washington, D. C. an intermittently-pulsed aerobic and anerobic system removed up to 80 percent of the nitrogen, thus drastically reducing the methanol requirements.

Recent experiments at Washington, D. C. and other localities have shown that biological removal of phosphorus can be achieved. Less than 0.55 mg/l of phosphorus was obtained in the effluent while meeting secondary treatment requirements. The system couples conventional aeration with rapid removal of solids from the clarifier. The solids are then anaerobically digested for 6 to 20 hours; the phosphorus in the sludge is released and precipitated in the side stream. The solids are then recycled to the aeration tank. The higher concentration of phosphorus in the side stream allows lower lime dosages for precipitation than full flow treatment.

#### Physical-Chemical

Physical-chemical methods are probably the most widely relied on in advanced waste treatment. Carbon in large complex molecules can be removed from wastewater by carbon adsorption. BOD$_5$ of 5 mg/l or less can be achieved. Gravity flow, pressurized downward flow, and pressurized upflow contact methods have been demonstrated utilizing a variety of size and gradation of media. The Piscataway, Md. plant is using carbon adsorption in a 5-MGD advanced waste treatment facility. Also, ozone oxidation of organic carbon has been shown to reduce the BOD$_5$ to substantially less than 5 mg/l in experiments in Washington.

The physical-chemical removal techniques for nitrogen include breakpoint chlorination, ion exchange, and ammonia stripping. Effluents containing less than 2.5 mg/l of total nitrogen have been produced with these techniques. Tests on breakpoint chlorination were conducted at Washington, and the method is being proposed for facilities in Cortland, N. Y.; Montgomery County, Md.; Gainesville, Fla.; Bucks County, Pa.; and Occoquan, Va. Ion exchange is being considered in Alexandria, Va. and Neosho, Mo. Ammonia stripping has already been used on full-scale installations in Orange County and South Lake Tahoe, Calif.

Lime, ferric salts, alum and aluminum salts are used in the physical-chemical methods of removing phosphorus. Addition of the chemical and precipitation can be done throughout the process—in primary sedimentation, in the secondary system, or as a separate final stage (often termed tertiary treatment). Many plants around the Great Lakes are using ferric and alum salts in either primary or secondary stages to reduce phosphorus. Lime can be used in primary sedimentation for phosphorus removal, as demonstrated in pilot studies in Washington, or as separate tertiary treatment as currently employed in a 5-MGD plant in Piscataway, Md., and in South Lake Tahoe, Calif.; Colorado Springs, Colo.; Las Vegas, Nev.; Monroe County, N.Y.; and in other locations.

**Land Application**

Land application techniques discussed earlier can be designed and operated as advanced waste treatment systems. Nutrients are removed as the wastewater comes in contact with the soil and are then available to plant life.

## E. Sludge Handling Techniques

An integral part of most wastewater treatment systems is the sludge handling facility. The removed pollutants and resulting chemical precipitant from the various unit processes must be processed to an environmentally sound condition for final disposal. There are several possible steps leading to final disposal: sludge stabilization, sludge thickening, sludge conditioning, and sludge dewatering. The goal of these processes is generally to minimize the noxious aspects of the sludge or remove the excess water to minimize the sludge volume to be disposed.

### Sludge Stabilization

Before sludge can be disposed, it must first be treated to reduce adverse impact on receiving land, air, or ocean. The term "sludge stabilization" is used to describe those methods which will reduce the detrimental impact of sludge disposal, i. e., render the sludge as innocuous as practical. The following are the primary requirements for "stabilization": Removal or treatment of the highly volatile portion of the sludge so that rapid decomposition, with resultant rapid oxygen consumption and the creation of odors, does not occur; rendering of toxicants in a form which would not immediately and adversely affect the environment; achievement of a high degree of kill or inactivation of various types of pathogens.

**a. Biological: (1) Anaerobic Digestion.** Anaerobic digestion, a widely-employed process, involves biological decomposition of organic sludges in an environment devoid of dissolved oxygen. The bacterial growth is inhibited by the presence of oxygen in the sludge and often is sensitive to heavy metals. The optimum temperature for bacterial action is from between 85° and 95°F; below about 70°F, their activity practically ceases. Anaerobic digestion reduces the volatile matter by 40 to 60 percent. Since anaerobic digesters must be at a temperature of from 85° to 95°F, heating of digesters is necessary.

Anaerobic digesters are designed for single-stage or two-stage operation. In the two-stage system, the sludge in the first-stage unit, where most of the biological decomposition takes place, usually is continuously mixed by gas-lift circulation, pumped recirculation system, or mechanical mixers. In the second-stage unit, there is often no direct requirement for heating or mixing; thus, a quiescent condition is provided which leads to settling out of the solids and a supernatant.

In general, the digestion proceeds for about 30 to 60 days in either the single- or two-stage system. Higher-rate anaerobic digestion of primary and activated sludge has been successfully practiced, but operations must be strictly controlled. After equilibrium, the solids are allowed to settle and are periodically removed for dewatering. The supernatant is normally sent back to the biological treatment plant because it is high in BOD, fine suspended solids, and nutrients. However, there must be assurance that such practice will not degrade the final effluent. Otherwise, it should be given proper separate treatment. The resulting sludge normally is dewatered.

**a. Biological: (2) Aerobic Digestion.** Aerobic digesters for stabilizing sewage sludge are being used more frequently because of their ease of operation compared with that of anaerobic digesters. The process basically consists of aerating sludge in a tank that is usually uncovered and unheated. The principal operating cost is the power required for aeration. The sludge is supplied with oxygen so that dissolved oxygen exists in all portions of the basin. The aeration can be accomplished by means of compressed air and porous diffusers, surface-type mechanical aerators, or submerged turbines supplied with compressed air (or oxygen). However, with relatively thick sludges (above 2 percent solids), it is almost impossible to dissolve and distribute oxygen throughout the entire sludge mass unless some sort of mechanical device is used.

Aerobic digestion is not as sensitive to temperature as anaerobic digestion. There is no great adverse effect from temperature variations from between 50 to 105°F. Normally a 10- to 15-day retention time is sufficient to stabilize the sludge and accomplish a reduction in volatile solids of from about 30 to 55 percent.

**a. Biological: (3) Composting.** (See the discussion of composting and final disposal in the section on "Land Utilization Techniques.")

**b. Chemical: (1) Lime.** The principal chemical process that can stabilize a sludge is the application of lime to obtain a pH of 11.5. It has been known for some time that applying lime to organic matter and raising its pH to above 11 will cause complex changes in the volatile solid matter, especially when such a lime-treated sludge is dewatered. If placed on the land, putrefaction will be suppressed for a considerable time; then, as the pH drops, gradual decomposition of the organic matter will occur with considerably reduced generation of odors. Furthermore, at a pH of 11.5, the destruction of organisms and inactivation of viruses are good.

**b. Chemical: (2) Chlorination.** Another chemical treatment that has been used recently to stabilize sludge and often enhance its dewatering characteristics is the addition of large dosages of chlorine. The equipment for this proprietary process consists of a pressure tank and recirculating pump (Purifax Process). The chlorine is applied to the raw sludge, which is pumped into a pressurized holding tank under about 45 psi and held there for from 10 to 15 minutes.

Experimental work indicated that dosages of 500 mg/l of chlorine added to each percent solids concentration of an organic sludge would eliminate odors; the color of the sludge changed from black to light tan. This chlorine dosage also increased the drainability of the sludge. The recycled liquor must be properly managed to prevent toxic or inhibitory effects to the rest of the plant.

**c. Physical Methods.** The only practical stabilization method that can be considered as being essentially physical is heat treatment. Since temperature of about 350 to 400°F can destroy pathogens and degrade a large portion of the volatile solids (see the later discussion of wet oxidation processes), the final sludge is considered stabilized and can be disposed on the land or in a landfill after dewatering.

Also, Pasteurization (150°F for about 1/2 hour) of liquid sludge has been considered in this country and is practiced at several localities in Germany. It destroys pathogens to a high degree, but does not stabilize the sludge since it does not reduce the volatile solids.

### Sludge Thickening

Since sludge from the main treatment stream is removed at concentrations normally well below 5 percent solids, the bulk of the sludge is water. The removal of this water is desirable for many efficient and effective disposal schemes.

**a. Gravity Thickening.** Gravity thickening is the most common sludge concentration process in use at wastewater treatment plants. The sludge particles may be separated from water by maintaining quiescent conditions. Gravity thickeners usually follow gravity clarification, sometimes in the same unit, but the emphasis is on removing water from solids rather than solids from water, as in clarification. In thickening, the predominant mechanism is settling. An advantage of gravity thickening is its simplicity. However, in some cases gravity thickening does not normally produce as highly concentrated a sludge as do other thickening processes.

Normally primary sludge thickens readily, and often separate thickening beyond that in the primary process is not necessary. Secondary treatment sludge from a biological process normally exhibits poor thickening characteristics and requires separate external thickening. Common practice often employs a separate thickening process for both primary and secondary sludges.

**b. Flotation.** Like gravity settling, flotation has been adopted for thickening waste sludges, especially organic sludges that do not thicken easily by gravity settling, such as waste activated sludge. To accomplish good thickening and to also achieve a relatively clear underflow, the raw sludge is frequently "conditioned" with either an organic or inorganic coagulant.

Flotation is accomplished first by taking a volume of relatively clear water (usually the underflow) and pressurizing it up to 30 to 70 psi. Air is injected into the pressurized liquid so that dissolution occurs. This pressurized liquid is then released through a specially designed valve to a pressure equal to the hydrostatic head in the flotation basin and mixed with the raw sludge. The drop in pressure causes microscopic air bubbles to come out of solution and attach themselves to the sludge particles or floc; thus rapid flotation results.

**c. Centrifugation.** Centrifuges have been primarily used in the wastewater treatment field for sludge dewatering; however, recently one type of centrifuge, known as the disk or nozzle type, is coming into use for thickening of activated sludge. The disk (or nozzle) type centrifuge has been used for many years in the chemical process industry, but its use for sludge thickening in the field of wastewater treatment is relatively new, and only a few installations exist.

### Sludge Conditioning

Sludge conditioning encompasses those processes which involve biological, chemical, or physical treatment (or their combinations) to make the separation of water from sludge easier. Also, it should be kept in mind that certain conditioning processes accomplish more than merely increasing the dewaterability of sludge; they may also alter the sludge chemically, disinfect it, destroy odors, and may even accomplish a certain amount of destruction of the sludge mass by liquifaction or oxidation in some processes.

**a. Chemical Conditioning.** Chemical conditioning is a method used to break down the gelatinous nature of sewage sludges which makes it difficult to separate the water from the solids. By adding certain chemical flocculants, the "bound" water can be separated from the solids with much less effort and cost.

The inorganic chemicals used for such conditioning are alum, ferrous sulfate and ferric chloride, and lime. Alum is used primarily to agglomerate the fine floc of an activated sludge to aid in its thickening. Ferric sulfate is not used much because of the difficulty of getting it into solution in cold water. Ferrous sulfate is used usually with lime. The most widely used inorganic conditioner is a combination of ferric chloride and lime. The pH is raised to from 10.5 to 11.5, and good conditioning is obtained. The high pH causes the death of many pathogenic organisms and the inactivation of many viruses. The precipitated ferric hydroxide is aided in conditioning the sludge by the precipitation of calcium carbonate from the calcium alkalinity in the water and the $CO_2$, thus adding weight to aid in thickening light sludges.

A great many of the new organic polyelectrolytes, especially of the cationic type, are effective flocculants and conditioners. Their use does not add any significant quantity of solids, which can be important in economic considerations for sizing an incinerator.

Many sludges that do not dewater readily without a large amount of conditioning chemicals can be dewatered easily on vacuum filters by adding a "filter aid" such as diatomite, fly ash from coal-fired power plants, or sludge incinerator ash. The production of fly ash from coal-fired plants is tremendous. It has been estimated that if all secondary wastewater treatment plant sludges produced in 1970 were dewatered using such fly ash as an aid, it would only use up about one-third of the total fly ash production. Such fly ash consists principally of silica and alumina, with varying amounts of iron oxides and carbon.

**b. Heat Conditioning.** It is generally acknowledged that heat treatment of sludges, especially those containing a large percentage of organic matter, will greatly improve their dewaterability. Wastewater sludge can be classified as being to a large degree a colloidal-gel system, and heating allows entrapped water to escape the gel structure. Some have referred to this as "heat syneresis."

Basically, this process involves the heating of partially thickened sludge in a closed reactor up to a temperature of 350° to 400°F at a pressure of about 200 to 250 psi, and holding it under these conditions for about 30 minutes.

**c. Freezing.** A detailed study to evaluate conditioning and dewatering of sewage sludge by freezing was sponsored by EPA and carried out by the Milwaukee, Wis. Sewerage Commission. The initial conclusion was that the freeze-thaw process had technical merit. However, the final conclusion was that the total cost of the process was greater than existing chemical conditioning processes. Other than cost another disadvantage appeared to be that it was essentially a batch process.

### Sludge Dewatering

All the various treatment processes to which the sludges have been subjected, such as thickening, stabilization, conditioning, etc., were directed, to a large degree, towards facilitating the removal of entrained water from the solids. This is termed "dewatering" so that the solids can be more economically and more readily disposed in an environmentally acceptable manner.

**a. Sand Beds.** The most common method of municipal wastewater sludge dewatering is on sand beds. Although sand beds are particularly suitable for small installations, they are used at treatment plants of all sizes and in geographical areas of widely varying climates. Many industrial sludges and water treatment plant sludges are also dewatered on sand beds. Generally, a well-designed and properly operated sand bed can produce a drier sludge than any mechanical dewatering device.

Dewatering on sand beds is by drainage and evaporation. The proportion removed by drainage may vary from 20 to 85 percent. Normally, most of the drainage is accomplished in the first two days on the bed; evaporation is the principal effect thereafter. After a few days, the sludge cake shrinks horizontally, producing cracks at the surface which expose additional sludge surface area and enhance drainage as well. The liquid draining from the sludge is often returned to the treatment plant. Though its volume is small, if the sludge being dried has been digested, for example, the drainage contains a high concentration of soluble organic matter, ammonia or nitrates, and phosphates. The sludge is removed by hand shovel or by a mechanical scraper device after one or more months of dewatering.

**b. Vacuum Filtration.** All types of municipal sludges —raw, digested, primary, activated, trickling filter, and mixtures—can be dewatered by vacuum filtration.

The rotary drum type of vacuum filter has been widely used for sludge dewatering. Basically, there are two types: the stainless steel coil filter and the belt filter, which uses a belt of fabric (usually synthetic) as the filtering medium.

The basic principle used by and of the wide variety of commercially available vacuum filters is suction. Mechanical equipment produces a vacuum on the inside of a drum. The vacuum draws the water from the sludge leaving a dry or dewatered sludge on the media side. The dewatered sludge is then removed for disposal.

**c. Centrifugation.** Again centrifugation can be and is used on a wide variety of municipal sludges. The basic principle is to separate the solids from the water by centrifugal force.

The unit generally used for wastewater sludge dewatering is the horizontal solid bowl centrifuge. It operates on a continuous basis and has produced a sludge cake of from 15 to 25 percent solids in normal operation.

Centrifuges require little space. However, in general, the solids capture is not as good as with vacuum filters unless optimum chemical conditioning is used, and then the cake invariably is not as dry. Centrifugation has been used successfully and competitively in practice in lieu of vacuum filtration.

**d. Filter Press.** The standard type filter press, or pressure leaf filter as it is sometimes called, has been used for many years in the chemical process industry for dewatering slurries. It consists of "leaves" covered with some type of porous fabric. These leaves or plates form a series of chambers; the sludge is retained between the fabric on both sides of the leaf. These plates are first pushed together and compressed by hydraulic or mechanical pressure exerted on the ends of the series of plates to prevent leakage. Drainage ports are provided in the plates for the liquid to escape. The pressure is imposed by pumping in the sludge which is retained between the filter fabrics. The final pressure can amount to several hundred psi, though usually for sewage sludge it is about 100 psi.

**e. Belt Filters.** Another type of filtering device used for dewatering sludge is the belt filter press. One form was first used in Europe and has been introduced to the U.S. market in recent years. It consists of two endless belts, normally made of finely woven stainless steel wire, traveling in the same direction but opposite to each other. Chemically conditioned sludge is fed continuously between the belts and is subjected to gradual pressure exerted by two individually adjustable rollers. The end product is a fairly dry sludge with solid concentration of approximately 15 percent.

This process is effective only when water and solid in the sludge are readily separable. Proper chemical conditioning prior to dewatering is therefore the key to the success of the belt filter press operation.

Another unique type of horizontal belt filter was developed in Europe and used for industrial type slurries. It depends on capillary suction action on the water portion of the conditioned sludge to extract the liquid from the sludge layer formed on top of a sponge-like belt. The liquid is squeezed out of the "sponge" belt, and the cake is further squeezed between steel rollers for additional dewatering. The sludge cake adheres to one of the rollers and is doctored off.

A unit that has been used fairly extensively is the so-called dual cell gravity concentrator. It has several unique features which produce dewatering of sludge through a synthetic porous fabric by the action of gravity. The first cell accomplishes the removal of the major portion of the water from a thickened sludge; then the sludge mass is carried over into a second cell where final dewatering is accomplished.

**f. Screens.** Specially designed self-cleaning metal screening devices are used (and are necessary) ahead of disk (or nozzle) type centrifuge thickeners for waste activated sludge.

At the Hyperion Treatment Plant in Los Angeles an unusual use is reportedly being made of fairly coarse horizontal and sloping screens, of the vibratory type, for removing the larger solids from digested sludge before it is disposed. The organic screened-out solids are macerated and returned to the main sludge stream, while the inert and hard materials are separated and hauled to a landfill.

Recently, a stationary sloping screen of an unusual design from a hydrodynamics standpoint has been introduced. The experience with it is still very limited, but it has application for non-flocculent type sludges, such as those from primary clarifiers and trickling filters, and for removing fibrous and discrete particles. The simplicity of design and low cost compared to other systems warrant its thorough testing and consideration.

### Final Disposal

In some of the processes used to dispose the sludge to the land, air, or oceans, the sludge must be dewatered to a high degree; in others, it is disposed in liquid form, usually after some thickening. Some processes, such as incineration, may merely dispose the organic portion leaving the ash and the liquid (if removed from the sludge before incineration) for further processing and/or disposal.

**a. Incineration.** Since the municipal wastewater solids and sludge (including grit and skimmings) that are generated have a large portion of organic matter, the burning of such sludge is a logical final disposal process. However, an ash remains for final disposal.

Whether the combustion is self-supporting depends on the calorific value of the solids and the degree of dewatering that was accomplished. The incinerators are always provided with auxiliary fuel for use when needed—such as during startups. Domestic wastewater sludge dewatered preferably to solids content greater than 30 percent will permit self-supporting combustion. Although either may be incinerated, raw sludge is preferable to digested sludge because of its greater calorific value.

Sewage sludge incineration has been practiced for many years and is becoming considered in urban areas as sludge volumes increase and as land areas for alternative operations become more scarce. Also, the development of greatly improved designs to control air pollution and possible recovery of the heat has increased the use of incineration. The incineration process must not produce objectionable smoke, odor, or other atmospheric pollutants.

Incineration achieves volume reduction and solids sterilization. The two most common types of sludge incinerators are the multiple hearth and the fluidized bed. A less common type is the flash drying and burning unit.

**b. Wet Oxidation.** In the wet air oxidation process, organic compounds in the sludge are chemically oxidized in the aqueous phase by dissolved oxygen in a specially designed reactor at temperatures of from about 500°F to 700°F and pressures of from 1,000 to 2,000 psi. The degree of oxidation achieved in the process can vary considerably, depending on sludge characteristics, temperature, and detention time. In practice, oxidations ranging from 70 to 80 percent in terms of decrease in oxygen demand are normally sought. Wet air oxidation of sludge produces a sterile, stable product that dewaters and filters readily. The process produces a sidestream when the oxidized sludge is thickened and dewatered, usually by settling, vacuum filtration, centrifugation, or a combination of these processes.

**c. Land Spreading of Sludge.** (See the discussion in the section on "Land Utilization Techniques.")

**d. Landfill of Sludge.** (See the discussion in the section on "Land Utilization Techniques.")

**e. Landfill of Incinerator Ash.** (See the discussion in the section on "Land Utilization Techniques.")

**f. Pyrolysis of Sludge.** Pyrolysis is a process involving the heating of organic matter in the absence of oxygen. The term "destructive distillation" is used when wood is subjected to this treatment to produce methanol. Depending on the nature of the organic matter, the decomposition of sludge by pyrolysis at temperatures varying from 900°F to 1,700°F produces compounds such as char, tars, various liquids, and gases such as hydrogen, carbon monoxide and dioxide, methane, and ethane.

**g. Composting and Final Disposal.** (See the discussion in the section on "Land Utilization Techniques.")

**h. Reuse of Treatment Plant Wastes.** (See the discussion in the section on "Reuse Techniques.")

## CHAPTER V: REUSE TECHNIQUES

Reuse and by-product recovery is one of the major techniques for handling wastewater. Uniform criteria for best practicable treatment cannot be set for reuse purposes, since some industrial reuse needs such as cooling and quenching require minimum treatment of domestic wastewater; in other cases, water of drinking quality or better must be achieved.

The reuse criteria for best practicable treatment are set according to the medium (land or surface waters) into which reuse water is ultimately discharged and reflect two considerations: (1) as a minimum, no greater pollutional effect should result than if treatment and discharge or land application criteria were employed. This is to ensure equity among municipal works and prevent degradation of the receiving waters through the indirect discharge of untreated domestic waste; (2) as a maximum, as few additional restrictions as possible should be imposed. This is to carry out the purpose stated in the Act to encourage wastewater reuse, particularly when such facilities will produce revenue.

For the above reasons, the reuse criteria for best practicable treatment require that the quantity of pollutants discharged from a reuse project, attributable directly to the publicly-owned treatment works, meet the minimum criteria for nonreuse techniques.

### A. Reuse of Wastewater

Reuse opportunities from wastewater treatment plants do not only include reuse of the effluent, although this technique is still the most important. Use of methane gas from anaerobic digestion, recovery of coagulant in systems employing lime precipitation, and regeneration of activated carbon are also possible.

The effluent quality required for reuse may vary as discussed earlier. In many cases, reuse may require additional treatment beyond nutrient removal. Often the problem is high dissolved-solids concentration, for which several methods have been proposed. The most advanced technology of dissolved-solids removal is reverse osmosis. Distillation, ion exchange, and freezing techniques are still in the research or small-scale pilot stage.

A major steel company in Baltimore, Md. obtains sewage which does not receive secondary treatment. The industry treats to its needs. Other systems, such as one being planned at the Central Costa Sanitary District, Calif., require advanced waste treatment prior to industrial reuse. The Central Costa facility is expected to be revenue-producing.

Recharging ground water, directly or indirectly, is also a potential reuse and is being practiced with increasing frequency in the arid Southwest. Also, in the East, Long Island, N. Y. is recognizing the need for ground water recharge and is planning a demonstration study. The prevention of salt water intrusion is also an excellent reuse opportunity. Direct reuse for drinking water is being practiced in Windhok, South Africa, but not in this country.

Another wastewater reuse is in development of arid land. Examples include grassland or golf courses watered with treated effluent, development of forest land (being researched at the University of Pennsylvania), and a recreation facility developed by Los Angeles County in Antelope Valley, Calif. New land application techniques are expected to provide conditions for producing sod, Christmas trees, hay, or even beef cattle. The treated effluent from the South Lake Tahoe, Calif. plant is pumped to a reservoir for eventual use in irrigation. Highly-treated wastewater from the proposed Upper Occoquan, Va. plant will be discharged to a reservoir used for water supply.

In a land application system the water recovered and used for subsequent irrigation is considered a reuse technique. That portion must comply with the irrigation requirements. Only the water remaining as permanent ground water must comply with the standards for land application.

Revenue-producing facilities are being considered with increasing frequency. A plant in the Central Contra Costa Sanitary District, Calif., is in the early design stage. It is expected to sell highly-treated effluent to industries, thereby saving major development of new water supplies.

### B. Reuse of Treatment-Plant Wastes

Reuse of treatment-plant wastes such as sludges, methane gas, and waste-activated carbon is also possible. For several decades, methane gas from anaerobic digestion of a sludge has been used for fuel, electrical power generation, and heat.

Sludge can also be reused. The sale of dried sludge as a soil-builder, a unique operation in Milwaukee, Wis., has been revenue-producing. Another technique, demonstrated in pilot studies in Washington, D. C. and in full-scale operations at Piscataway, Md. and South Lake Tahoe, Calif., recovers coagulant from a lime precipitation process. The organic sludge is incinerated; the calcium carbonate that results from lime precipitation is calcined back to lime for subsequent reuse. South Lake Tahoe also has facilities to reactivate the activated carbon spent in wastewater treatment.

Other sludge-reuse techniques are also being investigated. Acid treatment of alum sludges to recover alum is actually being used in Japan. Hydrolysis of organic sludges, which employs sulfur dioxide, heat and pressure, shows potential in producing animal feed. After the hydrolysis, evaporation concentrates digestible organics valued at 2 to 5 cents per pound. Organic and chemical sludges can also be used to condition barren soil and improve cashcrop potential.

### C. Integrated Reuse Facilities

Reuse techniques benefit from total area planning and increasing utilization of integrated facilities. One potential integrated facility is the proposed Delaware Reclamation Project, where wastewater treatment sludges, municipal refuse, and garbage would be composted, separated, and heat-treated. At another proposed facility in Montgomery County, Md., organic sludges would be pretreated and used as a supplemental fuel source in thermoelectric power production. The effluent could also be used to supplement cooling water. Other integrated concepts which have been widely used are incorporation of septic-tank treatment capabilities in a plant and the use of joint municipal and industrial treatment facilities.

## APPENDIX G

## ENVIRONMENTAL TEAM

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GPO 833-978